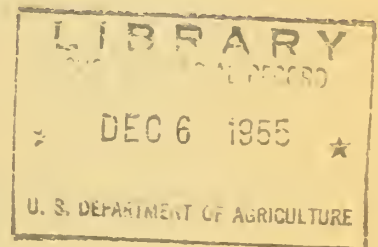


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The Caribbean Forester



U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

TROPICAL FOREST RESEARCH CENTER
RIO PIEDRAS, PUERTO RICO

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Tropical Forest Research Center

Río Piedras, Puerto Rico

On July 5, 1955 the activities of the Tropical Region, U. S. Forest Service in Puerto Rico were consolidated under the Tropical Forest Research Center. Dr. Frank H. Wadsworth, formerly Chief, Division of Forest Management Research, is the Research Center Leader.

The mission of the research center is three-fold; continuation of research in silviculture, forest management, and wood utilization; demonstration on a pilot scale of proper management and utilization practices in tropical forests; and technical training.



Centro de Investigaciones Forestales Tropicales

Río Piedras, Puerto Rico

Efectivo en julio 5 de 1955 se consolidó la Oficina de la Región Tropical del Servicio Forestal Federal como el Centro de Investigaciones Forestales Tropicales, bajo la dirección del Dr. Frank H. Wadsworth, anteriormente Jefe de la División de Investigación en manejo forestal.

Los objetivos del Centro de Investigaciones pueden dividirse en tres campos principales, a saber:

1. Investigación en silvicultura, manejo forestal y utilización de madera.
2. Demostración, en escala de planta piloto, de las mejores prácticas de manejo y utilización de bosques tropicales.
3. Programa de entrenamiento técnico.

Fifteenth Annual Report

Tropical Forest Research Center

U. S. Forest Service

Puerto Rico

The program of the Research Center during 1954 was characterized by a summing up of past forest management research in Puerto Rico, preparation for expanded research in the American Virgin Islands, and the inauguration of forest utilization studies in both areas.

In the field of forest management, observations were made as needed to maintain the 474 studies established prior to this year. Of these, 131 studies were terminated, and 13 new studies were begun. The relatively small number of new tests reflects concentration upon the preparation for publication of the results of past studies. The major publications in process of preparation during the year were a bulletin on forest planting in Puerto Rico, a book on the trees of Puerto Rico (in preparation jointly with Dr. Albert L. Little Jr. of the Division of Forest Management Research in the Washington office of the Forest Service), and a paper for the World Forestry Congress summarizing silvicultural experience in rain forest in Puerto Rico.

Six brief trips by staff members were made to the American Virgin Islands to examine preliminary regeneration tests in progress there and to make plans for an expanded research program to serve the new public forestry program of the Virgin Islands Corporation which is to begin in 1955.

The staff of the Center was increased by a full-time professional man in the field of forest utilization research who came late in February after 6 weeks of training in the Forest Products Laboratory at Madison, Wisconsin. The utilization research program is directed toward the discovery of new uses for the trees of Puerto Rico's forest for three major purposes:

1. To make available to Puerto Rico the full benefits of her remaining forest products, including the labor value involved in their preparation.
2. To provide a stronger economic basis for attracting private landowners to reforestation and forest management.
3. To serve as a guide for investigations in silviculture and regeneration.

Utilization research during the year has consisted largely of a survey of wood utilization in Puerto Rico and the Virgin Islands, the collection of additional data basic to a forest utilization problem analysis, and preparation for the development of new uses for Puerto Rican woods by local investigation of their properties.

Studies of the forest lands of Puerto Rico made jointly with a number of other agencies of both the Federal and Commonwealth governments have progressed a step further than was reported last year. Additional information as to the character and area of the different major soil groups became available in part as a result of the participation of the Center in an agricultural planning committee of the Puerto Rico Planning Board. A summary of the findings, presented in Table 1, shows that one-third of the land surface of Puerto Rico is suited primarily to tree cover; a larger area than had previously been estimated. Table 1 also suggests the relative priority of forest research on the different sites. Future tasks in this project are the mapping of these forest lands and the description of the physical, social, and economic conditions which characterize them.

Table 1.—Forest Problem Areas of Puerto Rico

Site	Slope	Area	Erosion hazard	Apparent forestry potential	Priority for research
A. The Mountains	%	M acres			
1. Humid tuffaceous loams	60+	170	High	High	I
2. Deep lateritic clays	60+	190	Moderate	High	I
3. Granitic loams	60+	59	High	Moderate	I
4. Laterites	5+	22	Moderate	Low	III
B. The Coastal Plain and Foothills					
1. Humid limestone	45+	150	Low	Moderate	II
2. Dry tuffaceous loams	60+	42	Moderate	Moderate	II
3. Dry limestone	15+	69	Low	Low	III
4. Tidal swamps	5—	16	None	Moderate	III
Total		718			

A reconnaissance of the Luquillo Forest was made with members of the administrative staff of the Forest Service to lay out major research and demonstration areas for future development. Two working circles have been reserved for intensive management of native forest and in two other working circles the native forest is to be converted gradually to broadleaf mahogany (*Swietenia macrophylla* King). Underplanting of this species is already being carried out in accordance with the plan.

Two distinguished visitors during the past year made helpful suggestions regarding the research program. Mr. Floyd M. Cossitt, in charge of planting for Region 8 of the Forest Service, made a thorough study of the problems of the nurseries of Puerto Rico and suggested a number of promising new techniques which might be tested locally. Mr. S. von der Recke, Chief, Latin-American Forestry Office of FAO, offered suggestions for site maintenance in eucalyptus plantations.

A brief survey of the forest problems of the island of Tortola was made at the request of the Commissioner of the British Virgin Islands. Most of the recommendations in the report were adapted from the findings of forest management research by the Center in Puerto Rico and the American Virgin Islands.

The Center was represented at a conference of a research committee of the Latin American Forestry Commission of FAO in Rio de Janeiro, Brazil, to consider a Latin Ameri-

can Forest Research and Training Institute. The Center in Puerto Rico was there considered to be one of the several national forest research institutions recommended for Latin America.

The training of foreign forestry students, in Puerto Rico, with emphasis on research, has continued. Thirteen students spent an average of 1 month each in training at the Center during 1954. A study of the forestry training potentialities of Puerto Rico made during a visit by Mr. Albert C. Cline, Foreign Forestry Specialist of the Forest Service in Washington, has led to preparations for an international tropical forestry training course sponsored by the Foreign Operations Administration to be held at the Center in 1955.

The Center has received substantial assistance and cooperation during the year from Federal and Commonwealth agencies in its program of research and related activities. The administrative branch of the Tropical Region of the Forest Service has assisted in the conduct and maintenance of field experiments in the Caribbean National Forest and in the preparation of the wood utilization laboratory. The Division of Forests, Fisheries, and Wildlife of the Commonwealth, as a result of joint plans made at the beginning of the year, has assisted in the conduct and maintenance of experiments in the forests under its administration, particularly in the Cambalache Experimental Forest. The Forest Products Laboratory generously trained the utilization special-

ist at Madison, Wisconsin and since has through correspondence offered much helpful advice concerning this field of research in Puerto Rico. The Virgin Islands Corporation financed the travel of research personnel and the field experiments in the Virgin Islands during the year. The Virgin Islands Experiment Station has provided both professional and subprofessional assistance in the conduct of experiments in St. Croix. The Soil and Water Conservation Branch of the Agricultural Research Service of the Department of Agriculture provided technical information used in the classification of forest lands and in a joint reconnaissance of the coffee region preliminary to research on tree shade.

FOREST MANAGEMENT RESEARCH

The more important results of investigations carried on during the year are here presented. Most of these are partial results from long-range studies not yet terminated. The findings are classified by the problem areas of priority I and II, as shown in Table I. An exception is the area of dry tuffaceous loams, for which no new important results were obtained during the year.

Humid Tuffaceous Loams

The objective of research in the humid tuffaceous loam area is the discovery of short-rotation economic forest crops preferably capable of establishment on bare lands. The results reported here concern the development of plantations in two experimental areas, the St. Just Experimental Forest, and the western extreme of the Luquillo Forest. St. Just is at an elevation of 300 feet and receives about 70 inches of precipitation annually. The Luquillo site is at an elevation of 1,300 feet and receives about 90 inches of precipitation annually.

Plantation Growth

Teak (*Tectona grandis* L.) is one of the best timber species capable of surviving field planting on this site. A 16-year-old plantation in the Luquillo Forest on an exposed slope has attained a basal area of more than 100 square feet per acre. The average crop tree is 5.9 inches in diameter, about 35 feet

tall, and is now growing at the rate of 0.20 inch in diameter per year. The form of the trees is not as good as on deeper soils, but the stand will yield better timber for farm uses than any other tested on this site to date.

Broadleaf mahogany (*Swietenia macrophylla* King), one of the most promising species for underplanting on this site, has continued to develop well during the year. Underplantings have been made beneath a nurse crop of casuarina (*Casuarina equisetifolia* Forst) and also under secondary forest. The planting beneath casuarina is particularly significant because it is near the top of a stony ridge and yet the trees are exceptionally vigorous, averaging 10 feet in height after 5 years. The thriftiness is at least in part due to the capacity of the casuarina to enrich the soil. The organic matter content of this soil has been increased in 8 years from 7.1 percent to 12.2 percent as a result of the establishment of the casuarina. In a nearby protected cove beneath secondary forest 10-year-old mahoganies now average 5 inches in diameter and range from 35 to 45 feet in height.

Mago (*Hernandia sonora* L.), a species utilized elsewhere for boxes and similar purposes, has proven well adapted to field planting on a lower slope at St. Just. Trees 9 years old average 3 to 5 inches in diameter and range up to 50 feet in height. Form is excellent. On a nearby upper slope the trees are less vigorous and only 25 feet tall, but even there the trees have grown better than most other species.

Two of the more insect-resistant species of bamboo (*Bambusa tuldoidea* Munro and *B. longispiculata* Gamble ex Brandis) have proven adapted to this site at St. Just, although their growth is inferior to that on deeper soils. After 5 years there are 18 mature culms in the average clump. These are less than 20 feet in height and only slightly more than 1 inch in diameter.

Summary of Status

These studies point to four prospects for forestry in this problem area. Teak is hardy and suited to field planting except possibly on the worst sites. It produces farm timbers in

a brief period. Mahogany is apparently also adapted but requires a nurse crop. It is less valuable at an early age than is teak. The mango and bamboo, while also adapted, require further research to develop a local market for their products. The bamboo, because of its extremely short period to harvest, might eventually prove the most attractive to private landowners. More extensive plantings of teak and mahogany in this area are warranted, and tests should be made with additional hardy but valuable species from elsewhere.

Deep Lateritic Clays

Research in this area is concerned with reforestation of bare lands and the improvement of fairly extensive existing forests. Both short rotation crops for private forestry and longer rotation crops for public forestry are needed. The results reported here come from research in the Luquillo, Toro Negro, Carite, and Guilarte Forests. At Luquillo the elevation of the experiments ranges from 700 to 1,500 feet and annual precipitation from 90 to 150 inches. At Toro Negro elevation ranges from 3,000 to 3,500 feet and precipitation from 110 to 120 inches. At Carite the elevation of the experiment is 2,400 feet and the rainfall is about 90 inches annually. At Guilarte the elevation is 3,000 feet and the rainfall is about 100 inches annually.

New Species

The interest recently developed elsewhere in Latin America in the prospect of using yagrumo hembra (*Cecropia peltata* L.) for paper pulp and the presence of rapid growing trees of this species in many parts of this area suggested that its propagation should be studied as a prerequisite to the possible need for uniform plantations. Two 50-gram samples of fruits produced an average of 10 grams of seeds, an extraction factor of 20. Two ½-gram seed samples had an average of 2,500 seeds, or the equivalent of about 2,200,000 per pound. Sowing in a nursery at sea level (below the natural range of the species) produced no germination in the sunlight. In half shade two samples germinated 2 and 9 percent. The seedlings were 10 inches tall after 6 months and transplanted bare-rooted without loss.

Plantation Establishment

The direct-seeded broadleaf mahogany (*Swietenia macrophylla* King) at 700 feet elevation in the Luquillo Forest has continued satisfactory development, although it has proved necessary to give early attention to liberation. The sowing, made under secondary forest, germinated nearly 100 percent and growth during the first 6 months was rapid. At the end of that period, however, growth decreased and further opening of the canopy was necessary. Now, after 18 months, the trees average 2 feet in height. The relative costs of direct seeding and planting have not yet been established. Each method has its advantages under special conditions.

Plantation Growth

Eucalyptus robusta Smith, a rapid growing species well adapted to elevations above 1,000 feet, has continued its rapid development in the older plantations into diameters approaching sawtimber size. In the Toro Negro forest a 13-year-old plantation has an average diameter for dominant and codominant trees (88 per acre) of 9.7 inches and a basal area of 129 square feet per acre. At Carite a 15-year-old plantation has an average diameter for dominant and codominant trees (36 per acre) of 12.7 inches and has reached a basal area of 157 square feet. Current annual diameter growth of the dominant and codominant trees is about ½ inch. In spite of the high basal area in these stands thinning does not appear to be needed because they have been invaded by grass and intolerant pioneer tree species.

Mexican cypress (*Cupressus lusitanica* Mill), now 5 years old at 3,500 feet elevation in the Toro Negro forest has made phenomenal growth. The average diameter of the trees is 5 inches and the average height 20 feet. The taper of open-grown trees is large but may decrease as the crowns meet. A few of these open-grown trees were used as attractive Christmas trees. Similar rapid development has taken place in a planting in the Guilarte forest. At low elevation (700 feet) in the Luquillo forest, on the other hand, trees are branchy, of

poorer color, and much less vigorous. A source of concern with this species is its very limited root system. A few trees have been wind-thrown as a result.

Primavera (*Tabebuia donell smithii* Rose) has continued its rapid growth at 700 feet elevation in the Luquillo forest. Seven-year-old trees growing with nearly full sunlight average 6 inches in diameter and 50 feet in height. Form is good despite the lack of side shade.

Plantation Management

Broadleaf mahogany (*Swietenia macrophylla* King) plantations at 800 feet in the Luquillo Forest are producing a satisfactory number of rapid growing crop trees after light thinning. Two 1937 plantations, thinned in 1949 and 1951, to 80 square feet of basal area, now contain between 96 and 124 dominant and codominant trees per acre. These trees, now 18 years old, average 8.8 inches in diameter with the range from 6 to 12 inches. Their average annual diameter growth ranges from 0.32 to 0.68 inch. Additional precommercial thinning may not be needed although the basal area in the past 3 years increased from 80 to 96 square feet per acre.

Another broadleaf mahogany plantation, now 26 years old, bears out the conclusion that rapid growing crop trees of this species

maintain their dominance even as stand density increases. This plantation increased in basal area from 105 to 124 square feet per acre in the period 1952-1954 and the dominant and codominant trees (84 per acre), mostly of good form, grew in diameter at rates ranging from 0.48 to 0.75 inch per year, compared to 0.32 inch for the intermediate trees. These crop trees range from 8 to 16 inches in diameter, the average, 12.2 inches. The very light thinning made 2 years ago induced the first seed crop, and natural regeneration has appeared beneath the stand.

Growth of Natural Forest

The completion of a composite board-foot volume table for tabonuco type forest in the Luquillo Mountains during the past year made it possible for the first time to compute board-foot volumes and increment in the growth plots. Heretofore volume increment has always been expressed in cubic feet, even though sawtimber, the object of timber management in the Luquillo mountains, is measured in board feet, because most of the volume of natural forests is in trees too small or unsuitable for sawtimber.

Board-foot volumes and increment were determined for three well-balanced cutover stands on comparable sites at elevations between 1,000 and 1,500 feet. The results are as seen in Table 2.

Table 2.—Increment per acre in Tabonuco Type Forest

Plot	Initial stand*			Subsequent net annual increment**
	No. trees	Basal area	Volume	
		Sq. ft.	Bd. ft.	Bd. ft.
El Verde No. 3	54	64	4,700	212
T-Cu-1	30	34	2,700	148
T-Cu-2	6	14	1,500	41

* Trees 10 inches dbh and over 8 years ago in El Verde No. 3 and 5 years ago in other plots.

** Includes ingrowth, mortality has been negligible during the period.

Table 2 shows clearly the need for substantial residual volumes in sawtimber sizes as a base for increment. Plot No. 3 has been considered dense throughout the period, yet has not been thinned. Its initial total basal area (2 inches plus) was 107 square feet per acre. For plot T-Cu-1 the corresponding figures are 91 and 120 square feet and for plot T-Cu-2, 67 and 102 square feet. The final basal area for trees 10 inches dbh and over in plot No. 3 had reached 83 square feet.

Improvement of Natural Forest

The natural forests of Puerto Rico are made up largely by trees of little or no commercial value. The silvicultural improvement of such forests is concerned with the elimination of inferior species from present stands but also with provision for regeneration of the better species for the future. Past experiments in the Luquillo Forest have shown that rain forest can be opened up to a basal area of 80 square feet per acre without causing invasion by vines and that such cutting can go a long way toward accomplishing the first objective, the elimination of the worthless trees. Preliminary observations during the past year in three plots in mixed secondary forest at an elevation between 1,200 and 1,800 feet have led to the conclusion that in most parts of this forest there is little prospect of inducing satisfactory composition in the regeneration solely by such improvement cuttings. The stands studied were cut over 2 years ago, and at that time 15 to 20 percent of their trees were of the better sawtimber species.

Re-examination after 2 years showed that the cutting produced an immediate growth response in the understory, but almost entirely in shrubs and sprouts of the less valuable tree species. The densely shaded forest floor now appears to be no better as an environment for seedling development than it was before the cut. There is no evidence of new seedlings of the desired species, and the advance reproduction of these species is being rapidly outgrown by sprouts. Thus, whereas the cutting has tended to eliminate a few inferior species, no marked improvement in the representation of the better species in the future appears likely.

The significance of these preliminary observations seems to be that partial cuttings in secondary rain forest of the tabonuco type may be justifiable if the trees eliminated can be harvested at a profit, or if a high quality stand remains which can accelerate in growth. On the other hand, such cuttings should not be expected generally to give rise to greatly improved composition in the next rotation. Artificial regeneration apparently is called for to assure this under these conditions. The conclusions from this study served as a partial basis for a paper submitted to the World Forestry Congress.

Summary of Status

Broadleaf mahogany is at this time the outstanding tree for this problem area, although it does not fulfill all requirements. Apparently for the best results it must be planted beneath existing forest or a nurse crop. It is growing well only on lower slopes and in coves below 2,000 feet elevation. It might eventually find a place in mixed coffee shade. Teak is also fairly well adapted to these lower slopes. Primavera is promising but its adaptability is still incompletely known. Casuarina grows rapidly below 1,500 feet elevation in this area, as does eucalyptus above this level, but neither species is yet of much commercial value here. Mexican cypress, on the other hand, is new but may prove an economically attractive crop for private landowners because of its adaptability for field planting and early utility.

The future of the natural forests in this area depends largely upon the development of new uses for the species common in them. Unless this can be done the trend will inevitably be toward gradual conversion to simpler and probably artificially regenerated stands.

The lack of a forest crop attractive to the owners of most of the land of this area calls for continued search not only for new tree crops but also for new utilities for those now known to grow well here.

Granitic Loams

The major objective of forest research in the granitic loam area is the discovery of trees adapted to field planting and producing a crop

attractive to private landowners. Research in the area this year has consisted of the periodic examination and measurement of plantations established in the past within the Luquillo and Carite forests, and more recently, tests of reforestation with new species in the Caonillas Valley. The study here reported is in progress in the Luquillo mountains at an elevation of 650 feet with about 110 inches of rainfall annually, near the wet extreme for this problem area.

Plantation Growth

Most of the forest plantations within this area are too small in area to provide an adequate basis for measuring their development. A tree of outstanding growth raised by tobacco farmers on this soil is casuarina (*C. equisetifolia* Forst.) It produces in a few years their requirements for the construction of tobacco barns. A tree of greater utility is needed, however, to cover large areas now idle and not needed for casuarina. One possibility may be broadleaf mahogany (*Swietenia macrophylla* King) as is indicated by a 16-year-old plantation in the Luquillo Forest. This plantation has attained a basal area of 107 square feet per acre, and the average diameter of the dominant and codominant trees is 8.7 inches. This rate of development compares favorably with that on deep clay soils and suggests that the underplanting of this mahogany beneath the casuarina plantations on this site might well be as successful as it is proving on the humid tuffaceous loams.

Summary of Status

General observations in this area indicate that the loose soil is favorable for tree growth. Soil protection and economic returns might be obtained by planting coffee with tree shade but there is little evidence of a trend in this direction. Casuarina grows well but the present market will absorb the production from only a small area. *Eucalyptus robusta* Smith apparently will also grow well but again is of little demand at present. Mahogany is handicapped by its comparatively long sawtimber rotation. The best prospect appears to lie in

further testing of new species with short rotation prospects, such as Mexican cypress and bamboo. Concurrent with these tests must go the exploration of markets for the products.

Humid Limestone

The humid limestone region, extending almost the length of the north coast of Puerto Rico, is an area of shallow rocky clay soils, mostly hilly and already covered with secondary forests. The lower, more protected slopes apparently are potentially a good forest site, but because of their accessibility few trees of good species remain. Reforestation is less a problem than the introduction of superior species into existing stands. The studies here reported are located in the Cambalache Experimental Forest at sea level with about 60 inches of rainfall annually, in the Rio Abajo Forest, at 1,100 feet elevation with 80 inches of precipitation, and in the Guajataca Forest at 500 feet elevation with 70 inches of rainfall annually.

Plantation Establishment

Primavera (*Tabebuia donnell-smithii* Rose) one of the most valuable timbers of Central America, was reported 2 years ago as slow growing in a recent underplanting in the Cambalache Forest. Trees set out beneath a secondary stand on a protected lower slope became chlorotic and made almost no growth despite openings in the canopy immediately above them. During the second year half the remaining shade was removed with almost no effect. In 1954 all shade was removed, and growth response was seen within 2 months. The trees have lost their former chlorotic appearance and are now shooting upward in the spectacular way they have grown in the open on the deep clays. The tallest trees are now 8 feet in height and the plantation appears well established. This species apparently is suited better for reforestation than for underplanting on this site.

Cedro macho (*Hieronyma clusioides* (Tul.) Griseb.), underplanted in the Guajataca Forest, unlike primavera at Cambalache, has

made slow but continuous growth beneath light shade. After 2 years the trees range between 30 and 48 inches in height, and no need for early liberation is apparent.

Mexican cypress (*Cupressus lusitanica* Mill), described elsewhere in this report as very promising at high elevation, has generally appeared much less adapted to low elevations. Trees at sea level usually become poorly formed, weaken, and frequently fall over. In 1952 underplanting in the Rio Abajo forest the trees appeared so weak until the past year as to be destined for failure. However, as a result of recent complete liberation from shade the trees now appear to be growing as well as at higher elevations. Now, after 4 years, the trees range between 10 and 15 feet in height and are beginning to dominate the site. This species will apparently not withstand much shade under these conditions and therefore should not be underplanted.

Plantation Growth

Small-leaved mahogany (*Swietenia mahagoni* Jacq.) one of the timber trees best adapted to the drier hills in this problem area, continues to make fairly satisfactory diameter growth in the older plantations, but in some areas height growth has declined and the development of well formed dominants is not taking place as it has with broadleaf mahogany elsewhere. An 18-year-old plantation on a lower rocky slope in the Guajataca forest has attained a basal area of 73 square feet per acre and the dominant and codominant trees average 6.1 inches in diameter. The average annual diameter growth of the dominant and codominant trees during the past 5 years has been 0.20 inch. Despite the present density of this plantation most of the trees are limby and few will produce a straight log of 12 feet in length.

Cedro macho (*Hieronyma clusioides* (Tul.) Griseb.) in the Rio Abajo forest has proven to be a tree of excellent form but of moderate growth rate. Growing on a formerly farmed sinkhole bottom, 15-year-old trees range from 3 to 6 inches in diameter and to 45 feet in height.

Bamboo (*Bambusa tulda* Roxb.) underplanted on a lower slope in the Cambalache forest 7 years ago has continued rapid growth in the areas of deeper soil. Clumps in these protected areas now are 30 to 35 feet tall and have from 5 to 14 mature culms of large diameter. On exposed slopes survival has been high and the culms are 25 to 30 feet tall but only one or two mature culms of large size have been produced per clump. There is a good prospect that this bamboo will eventually dominate the natural vegetation in this plantation.

Teak (*Tectona grandis* L.) has proven adapted to the sinkholes between the limestone hills in this area. The growth of some of the better stands has been measured periodically. One such plantation, established in 1938, had by 1951 attained a basal area of 90 square feet per acre and an average tree diameter for the dominants and codominants of 6.3 inches. This stand was then thinned to 80 square feet of basal area and now, 3 years later the basal area had increased to 103 square feet. It was again thinned to 79 square feet removing nearly all remaining trees of inferior form. The average diameter of the remaining dominants and codominants, now 16 years old, is 7.2 inches.

Plantation Management

The value of light shade over small-leaved mahogany in inducing good tree form is evident in a 10-year-old plantation in the Cambalache forest. The trees in this plantation, established by direct seeding, are nearly all of good form and with only small lateral branches. They range from 8-10 feet in height at the top of the slope to 12-20 feet at the bottom. Growth has been inhibited by the retention of shade for the first 8 years but the better tree form should be good compensation.

Ucar (*Bucida buceras* L.) a construction timber species native to this area, also requires light shade to develop well formed trees. A 10-year-old underplanting on a lower slope in the Cambalache forest contains trees 8 to 15 feet tall with erect form and few side branches. A nearby open grown plantation of the

same age has trees from 30 to 45 feet tall but these are excessively branchy, none with a straight bole 12 feet long. It is clear that some compromise is desirable here. The underplanted trees were completely freed of overhead shade after 8 years in the hope that rapid growth will now take place on the well formed stems.

A heavy thinning in a rapid growing broadleaf mahogany (*Swietenia macrophylla* King) plantation in the Rio Abajo forest showed that such stands can close the openings created before vines become a problem. In 1951 a 12-year-old plantation was thinned from 90 to 42 square feet of basal area. In the residual stand there were 116 dominant and codominant trees per acre with an average diameter of 6.4 inches. In 3 years the basal area increased to 57 square feet per acre and the dominant and codominant trees now average 7.8 inches in diameter. The most outstanding dominant trees (8 per acre) averaged 0.8 inch in diameter growth annually during the past 3 years. The thinning, which removed nearly all malformed trees, should not have to be repeated until the stand reaches merchantable size.

Summary of Status

The best adapted valuable tree species for this area is broadleaf mahogany. It is adapted only to the more humid lower slopes but can be inexpensively established in the extensive secondary forests by underplanting, and its growth to date has been rapid. On the upper slopes and drier sites small-leaf mahogany and maria (*Calophyllum antillanum* Britton) have proven adapted but data on their growth rates and prospects for yields are not yet sufficiently favorable to be attractive to land owners. Intensive private forestry on these upper slopes seems a dim prospect unless some culture such as bamboo can prove successful and attractive. Tests of bamboo to date are generally favorable but more time is required for conclusive results, and markets would then have to be developed. Primavera, and mahoe (*Hibiscus elatus* Sw.) can grow on the lower slopes but establishment there requires deforestation and costly weeding. Teak has so far

been found adapted only in the sinkhole bottoms, a very small proportion of the area. Cedro macho and ucar produce wood considerably inferior to mahogany but might prove of value if the mahogany plantations should ever fall victim to root rot as in Trinidad.

The American Virgin Islands

The objective of research in the Virgin Islands is to develop cheap methods to increase the representation of small-leaved mahogany (*Swietenia mahagoni* Jacq.) and broadleaf mahogany (*Swietenia macrophylla* King) in extensive existing secondary stands. The experiments here described were conducted on St. Croix on shallow tuffaceous soil with rainfall ranging from 45 to 60 inches annually.

Plantation Establishment

The appearance of natural regeneration of broadleaf mahogany (*Swietenia macrophylla* King) at Davis Beach in northwestern St. Croix suggested the possibility of direct sowing or broadcasting the seed of this species to avoid problems of artificial propagation. A broadcasting of 5 pounds of seed beneath an opening in the forest at Annaly Estate produced germination of 38 percent of the viable seeds. Examination at the end of 1 year showed that two-thirds of the original seedlings had survived and were growing. Direct sowing of seeds at a depth of $\frac{1}{2}$ inch was a complete failure. Seed tests made during the experiment showed viability to be very low, so the tests are to be repeated. However, the results indicate that broadcasting of this species may well have a place in these islands where labor is relatively scarce.

Growth of Natural Forest

Stands of nearly pure small-leaf mahogany (*Swietenia mahagoni* Jacq.) have become established naturally in the hills west of Christiansted, St. Croix. These stands are on typical forest soils and have been sampled to determine the growth rate which can be expected under these conditions.

Two-year remeasurement in three small growth plots point to the desirability of keeping the stands fairly open. In an old stand near the top of a ridge in Bellevue Estate with

an average diameter of 7.5 inches and a basal area of 102 square feet per acre the average annual diameter growth of the dominant and codominant trees is only 0.07 inch. This slow growth probably reflects extreme competition for moisture and might be accelerated by thinning.

Near the bottom of a nearby slope two additional plots show growth to be more rapid in younger stands. In one plot, with an average diameter of 3.9 inches and a basal area of 80 square feet per acre the average diameter growth of the dominant and codominant trees is 0.17 inch annually. In the second with an average diameter of 4.4 inches and a basal area of 68 square feet per acre the corresponding average diameter growth is 0.30 inch annually, almost twice as rapid.

Whereas it has not been established that the site at the top of the hill is comparable to that at the bottom, the relationship of diameter growth to basal area at the bottom of the hill suggests that the density of the stand on the ridge is probably excessive.

Summary of Status

The spreading of the two mahoganies through the forests of the Virgin Islands is still the major objective. Although the growth rate of the mahoganies is not as rapid in the Virgin Islands as in the more humid parts of Puerto Rico it is apparently at least as good as the other comparatively worthless tree species there. The mahoganies are apparently adapted to nearly all sites, as is indicated by abundant natural regeneration beneath old trees. The problems of establishment are related directly to the character and severity of the winter and spring dry season. The lack of surface water makes nursery propagation costly. The most promising approach to the problem seems to be the search for techniques for seeding directly in the field. More extensive tests of broadcasting and direct sowing are planned for 1955.

FOREST UTILIZATION RESEARCH

Brief reports were prepared at the request of the Commonwealth and private concerns on the possibilities of manufacturing hardboard in Puerto Rico, the manufacture of wooden

containers, use of bamboo for novelties and baskets, the availability of certain species for export, the possibilities of manufacturing wooden pallets, and other problems. Numerous other requests have been handled by letter or conference.

A laboratory was set up and a plan prepared during the year for determining the machinability and certain related physical and mechanical properties of 100 native woods. An unused building was remodeled and new woodworking machines were purchased and installed. Assistance was also given to the Division of Forests, Fisheries and Wildlife of the Commonwealth in planning of their research in forest utilization. Some time was used assisting an FAO representative and the Governor's committee in the Virgin Islands in a conference on the possibilities of local paper manufacture.

Survey of Wood Use in Puerto Rico

More than 600 industrial and agricultural contacts were made to determine the pattern of wood use in Puerto Rico. The survey showed the present use of native lumber to be less than 850 M board feet annually. This volume was used almost exclusively for furniture (316 M bd. ft.), farm buildings (estimated at 200 M bd. ft.) and hewn railroad ties (320 M bd. ft.). Sizable quantities of poles, posts, and fuelwood or charcoal are also used on the farms. Between 80 and 90 million board feet of lumber and lumber products are imported annually.

All uses of native lumber and other forest products are diminishing yearly due to the antiquated and inefficient logging methods (\$50.00 to \$100.00 per M), the lack of knowledge concerning the characteristics and proper use of native woods, very poorly manufactured lumber resulting from pitsawing and poor milling facilities, and the total lack of dry kilns or treating plants.

The furniture industry (206 plants) uses annually about 8 million board feet of imported lumber, mostly mahogany from Mexico, and nearly 3½ million square feet of plywood, largely baboon from Surinam. A large volume of

well manufactured native lumber could be used in this industry. Millwork manufacture (38 plants) use $1\frac{1}{2}$ million board feet of lumber, mostly southern yellow pine, and $1\frac{1}{3}$ million board feet of plywood annually. Some 650,000 wooden containers are imported yearly for exporting fruit and vegetables, $2\frac{1}{2}$ million board feet of railroad ties are imported from the United States and Dominican Republic, and more than \$400,000 worth of utility poles, brackets, and crossarms are imported annually from the United States. Most all burial boxes are made of imported wood, using nearly $\frac{1}{2}$ million board feet of lumber and nearly $1\frac{1}{3}$ million square feet of plywood annually.

Urban construction is almost entirely of concrete with interior trim and doors of mahogany. Rural housing and farm buildings are usually of concrete or southern yellow pine. Low grade pine and fir plywood are used almost exclusively for form lumber in concrete construction.

The several hundred manufacturing concerns ship almost all products locally and overseas in paper boxes despite heavy damage in transit, as all box shooks must be imported

from the United States. Imported box shooks are so expensive that a local box plant is needed. This plant could also supply the 650,000 fruit and vegetable containers required annually. These potential markets are increasing rapidly with the mounting industrial and agricultural production.

All of these industries and many others would use native lumber if it were available in quantity and quality comparable to the imported woods. This provides a huge future market for the present and future forest volume whenever it becomes available. A complete report on this survey is being prepared for publication.

PUBLICATIONS

Marrero, José

Especies del género *Inga* usadas como sombra de café en Puerto Rico. *Carib. Forester* 15:54-71.

Wadsworth, Frank H.

Tropical Rain Forest. General Papers of World Forestry Congress: 65-72. Dehra Dun.

A Report on the Tropical Forestry Short Course Held in Puerto Rico, March 1 to May 29, 1955

Frank H. Wadsworth, B. J. Huckenpahler
and Carl F. Ehelebe¹

The rapid expansion of bilateral and multi-lateral program of international forestry training has brought to Puerto Rico an ever-increasing number of trainees. Trainees who come to the United States from countries with tropical forests, and particularly those from Latin America, generally are scheduled to spend a considerable part of their training period in Puerto Rico, the only tropical outpost of United States forestry.

The training of individuals is less efficient than group training. Individual training requires a large amount of instructor time per trainee and seldom permits adequate coverage of a broad field in the brief period usually allotted. In an effort to eliminate these problems, an organized short course was proposed for early 1955. Added advantages recognized for group training were the prospects for justifying the use of outside specialists as instructors and for holding round tables in which mutual problems of national policies and programs could be described and discussed by the students themselves to the advantage of all present.

DESCRIPTION OF COURSE

The Foreign Operations Administration undertook to sponsor the course, recruiting most of the trainees and financing a Training Officer, a Group Leader, most of the instruction, and the travel and subsistence of trainees. Closely cooperating was the Food and Agriculture Organization of the United Nations which also sent part-time instructors, trainees, and teaching materials. The Caribbean Commission was instrumental in the recruitment of three trainees.

The direction of the course was a responsibility of the Tropical Forest Research Center of the U. S. Forest Service, in Puerto Rico. In this work the Forest Service was assisted by several agencies of the Commonwealth of Puerto Rico, particularly the Division of Forests, Fisheries, and Wildlife of the Department of Agriculture and Commerce, the Office of Technical Cooperation of the Department of State, and the Agricultural Extension Service of the University of Puerto Rico. Other federal agencies in Puerto Rico were also of assistance, particularly the Soil Conservation Service of the Department of Agriculture.

Subject Matter

The training course was intended to meet two needs, (1) that of technical men in junior positions in forest services for information concerning practices and techniques, and (2) that of chiefs and other senior men for information relating to broad policies, organization, administration, and legislation. A period of 2 months was allotted to cover the first phase and 1 month for the second. In the belief that the second phase would tie together the information presented in the first phase by showing its place in a national program, the second phase was scheduled to follow immediately after the first, with the junior men remaining for the entire 3 months.

The subject matter fields presented, in the order scheduled, are outlined in the following tabulation:

¹/Respectively —Research Center Leader and Training Officer, Tropical Forest Research Center and Group Leader, Foreign Operations Administration.

Subject	Days allotted	
	Lecture	Field or Lab.

Session on Practices, March 1 - April 29

Orientation on Puerto Rico, forests and forestry	3	—
Dendrology	2-1/2	1-1/2
Ecology	1/2	1
Regeneration	2-1/2	6
Silviculture	1	5-1/2
Mensuration	1-1/2	6-1/2
Utilization	1-1/2	3-1/2
Research	1	3-1/2
Other related forestry subjects	4	—
Subtotal	17-1/2	27-1/2

Session on Programs, May 2 - May 27

Forest resources	—	3
Forest economics	1	—
Public forestry	2-1/2	1
Private forestry	1	1
Forest legislation	1	—
Forest research	1	1
Problems and policy in countries represented	3	—
Other related forestry subjects	1-1/2	—
Allied governmental programs	—	4
Subtotal	11	10
Total	28-1/2	37-1/2

The orientation at the beginning of the course was broad and was offered by local leaders in the fields of political science, industry, education, and agriculture. Related forestry subjects, 12 of which were added at the request of the students, included special discussions on forest industries, forest inventory, aerial photography, regeneration with taungya, introduction of exotics, regeneration of dry regions, plotless cruising, silviculture of mahogany, pasture management, conversion of unmanaged stands, and logging. Allied governmental programs included those of the Agricultural Extension Service, the Soil Conservation Service, the Agricultural Experiment Stations, and the College of Agriculture. Other points of interest visited were a sugar mill, a pineapple

cannery, and a hydroponics farm. A day-to-day schedule appears in Appendix A.

Instructors

The central core of the instruction was carried out by personnel of the Forest Service stationed in Puerto Rico, including both the administrative and research branches of the Tropical Region. Such personnel led the instruction in the fields of regeneration, silviculture, mensuration, utilization, research, and public forest administration. However, the scope of the course was so broad that it was considered necessary to recruit a number of additional instructors from other agencies both from within and outside of Puerto Rico. The types of contributions made by these agencies are listed in Appendix B.

Trainees

The announcement of the course stated that candidates for the full 3 months should be "junior government officers from tropical countries who occupy positions having to do with forest resources administration, management, or utilization, or with closely allied fields. They preferably should be graduate foresters or agronomists engaged in forestry services, or have equivalent training." Trainees for the final month were to have equivalent training and to hold senior positions in their forest departments. Because of physical limitations a maximum of 20 trainees in each category was set. It was assumed that a country would profit most from the course by sending both a junior and a senior man.

A total of 14 trainees attended the first 2 months of the course and an additional 12 trainees the last month. Of this last group seven were sponsored by FOA (three of these recruited by the Caribbean Commission) and the others by FAO. The name of each trainee, his home country, and his period of training are presented in the following tabulation.

Three Months of Training

Boman S. Bhathena	— India
Roberto Chávez	— Mexico
Jorge A. Gallegos Terán	— Ecuador
Julio García	— Colombia
Alapatt I. Iyppu	— India
T. Jeyadev	— India
Thi Nghia Ly	— Viet-Nam
Arnoldo Madriz	— Costa Rica
C. M. Mathur	— India
Luis A. Palma N.	— Nicaragua
Claude C. Pierre-Louis	— Haiti
C. V. K. Reddy	— India
Martin R. Reyes	— Philippine
James Sánchez	— Colombia

One Month of Training

Virgilio H. Alvarado	— Guatemala
Jairo Alviar	— Colombia
Rene L. Ambroise	— Haiti
Flavio P. Bazán	— Perú
Albert A. M. Berenos	— Surinam
Kenneth K. Cheong	— British Guiana
Armando Cuevas López	— Mexico
Roberto C. Garduño	— Mexico
Luis A. Macías	— Mexico
Eduard S. Molgo	— Surinam
Alfredo Pinillos	— Guatemala
R. A. de Rosayro	— Ceylon

Facilities

The lectures were conducted in the library of the Forest Service headquarters building; the wood laboratory, nursery, and herbarium at the headquarters were also used. The group included both English and Spanish speaking trainees so translation was necessary. Translation of lectures was done by members of the staff. The translation was generally briefer than the original presentation and was frequently unnecessary in the field. The more important information was mimeographed in both languages. A list of the material distributed to the trainees appears in Appendix C and the educational films shown are listed in Appendix D.

Most of the field work was carried out on the public lands within two Federal and seven Commonwealth Forests. Field work was done also on farm areas and in the two forest nurseries of the Commonwealth. Field quarters were used temporarily to house the students in the Luquillo, Toro Negro, Río Abajo, and Maricao forests. A total of 12 nights were spent in the field. Travel was in sedans and station wagons, some of which were rented by the day. A total distance of 2,700 miles, nearly all on hard surfaced roads, was covered during the

3 months. About 30 percent of the field time (16 percent of the total time) was spent in travel.

Accommodations

The desire to assure satisfactory quarters at reasonable rates and to locate the trainees close to the Forest Service headquarters and to each other led to the proposal to set up a cooperative which was agreed to and financed by the trainees. This cooperative, administered by the Group Leader, rented adjacent apartments in a large apartment building. The visiting instructors and all but three of the trainees participated in this arrangement. An average of five men shared each apartment.

Meals were also provided through the cooperative. An extra apartment was rented for a kitchen and dining room, a cook and helper were hired, and food was purchased. When required, the cook, cooking equipment, food and bed linen were transported to the field with the trainees. On weekends the cook was off duty and many of the men cooked their own meals in each apartment, others eating in restaurants nearby. The cooperative fund was also used to finance other projects jointly agreed upon, such as special meals, banquets, and a few trips.

Outside Activities

A number of outside nonforestry activities were arranged for the trainees. These included six dinners, of which three were in private homes; four cocktail parties, two receptions, two dances, two tours of historic sites, two trips to the beach, one concert, one trip to an outdoor recreation area, a trip to the phosphorescent bay, and attendance at the opening of the West Indian Conference, religious activities, and the dedication of the International Airport. Several of these activities were arranged by the Office of Technical Cooperation of the Commonwealth Department of State.

In addition, the cooperative dining room facilities made it possible for the group to invite friends to meals. In all about 50 persons, including several prominent officials,

ate with the group as guests. Outsiders were also invited in to see the films shown in the dining room during the evenings.

A conscious attempt was made in planning the program of the course to integrate cultural, aesthetic, and recreational features at appropriate opportunities, and above all, to show wherever possible how these features were related to the forestry programs of Puerto Rico to provide vivid experiences for the participants. Whenever possible lunch stops or evenings in the field were scheduled for places which offered excellent examples of typical features of Puerto Rico.

MAJOR ACCOMPLISHMENTS

The major accomplishments of the course appear to lie within three general categories: (1) the dissemination of information on tropical forestry, (2) the unification of the trainees regarding professional matters, and (3) the broadening of general understanding.

The instructors showed forestry to the trainees, supervised their actual participation in certain types of forestry work, and in addition described for them other practices, techniques, and aspects not locally demonstrable. They were shown all of the important results of 30 years of forestry and allied activities in Puerto Rico. They saw the more important tree species, the different forest types, the results of reforestation of bare land, underplanting with mahogany, improvement cuttings in natural forest, and the effects of orderly forest management and administration. They were also shown how to prepare samples for wood testing, a furniture factory, paper mill, and paper-board box factory, and the methods and practices used in local programs of soil conservation, agricultural extension, research, and education.

In addition to being shown, the trainees themselves carried out a number of forestry projects calling for direct participation. They marked a plantation of teak for thinning and saw it thinned, they marked trees for an improvement cutting in mixed rain

forest, they made a simple volume table for eucalyptus, they carried out a 10-percent inventory of 335 acres of rain forest and computed the volumes of trees suited for furniture wood, construction wood, poles, posts, and fuelwood, determining also the volume which should be removed to improve the stand. They also determined for 50 species of trees in rain forest the growth rate during the past 12 years. In the study of woods they dipped lumber for protection against stain and stacked it for air seasoning. They determined the specific gravity, shrinkage, and moisture content of wood and used woodworking machines in making small objects.

The instructors described many additional aspects of forestry which could not be easily demonstrated. Included were the testing of seeds, nursery practices, inventory methods without plots, the planning and layout of experiments, the parcelero system of forest farming, organization of the United States Forest Service, and policies and practices of forest administration in the United States.

All of the training did not emanate from the instructors. In roundtable and outside discussions the students themselves contributed much information of common interest. During a period of 3 days each trainee had an opportunity to describe individually the forest conditions and problems of his country. These were discussed by the entire group. In addition, the trainees gave lectures and led discussions on subjects of special interest to them, such as regeneration with taungya, the regeneration of dry sites, the introduction of exotics, and grazing problems.

The training had a pronounced effect in unifying the men. They lived together and with many of their instructors. Differences in rank among the trainees created no problem. Through the course they became increasingly aware of the nature of their respective problems, many of which are common for Latin America. It was thus logical that at the close of the course they expressed a desire to maintain contacts and to meet again periodically to discuss frankly their problems.

The general understanding of the trainees, particularly those from the Eastern Hemisphere, was broadened by the course. The orientation clarified the status of Puerto Rico with respect to the United States, and described the government and its progress in education, agriculture and industrialization. Moreover, the trainees traveled to all parts of the island. They met local leaders and learned of life in the island through the numerous special contacts. In addition, they learned how people live in the 13 other countries represented by their fellow trainees with whom they were so closely associated.

An additional measure of performance is the safety and health record of the trainees and instructors. The course involved about 1,750- man-days, including trainee time, and more than 12,000 car-miles, yet there were no lost-time accidents and only 1 man-day of sickness.

APPENDIX A

Program for March

Date	Activity
1	Physical Arrangements, Housing, etc.
2	Welcoming Address
3	Talk on Course Administration Talk on Education in Puerto Rico Talk on Economic Development in Puerto Rico Talk on General Orientation Talk on Agriculture in Puerto Rico
4	Lectures on Forest Problems of Puerto Rico Land Watershed Protection Timber Supply Utilization Wildlife Recreation Lectures on Development of Forestry in P. R. Before 1900 U. S. Forest Service Commonwealth Div. of Forests,

	Fisheries and Wildlife Extension Service		Field Study of Forest Plantations Guajataca
	Soil Conservation Service	22	Regeneration
5	Reception for Trainees		Field Study of Forest Plantations Luquillo
7	Dendrology		Regeneration
	Lecture on Nomenclature and Classification of Trees	23	Field Study of Forest Plantations at Carite
	Laboratory Work on Botanical Terms	24	Regeneration Summary
8	Dendrology		Silviculture
	Tree Identification - Use of Keys		Lecture on Silvics and Silviculture
	Lecture on Ecology		Lecture on Tropical Silviculture
9	Dendrology and Ecology		
	Field Trip to Cambalache Forest		
10	Dendrology	25	Silviculture
	Lecture on Important Families of Forest Trees		Mark Teak Plantation for thin- ning at Río Abajo
	Collection of Botanical Specimens-Herbarium		See Thinnings of Teak and Mahogany
			Study Marked Teak Plantations after Thinning
11	Dendrology and Ecology		Return to Río Piedras
	Field trip to Luquillo Mts. and El Yunque	28	Silviculture
12	Dendrology		See Thinnings in Mangrove at Aguirre
	Lecture and Examination		
14	Regeneration	29	Silviculture
	Lecture on seed collection and testing		Observe Effects of Timber Cutting at Luquillo
	Seed Tests at Río Piedras Nursery	31	Silviculture
15	Regeneration		Practice Timber Marking at Luquillo
	Lecture on Nursery Practices		
	Orientation and Political Development of P. R.		
	Regeneration - Visit Toa Nursery		
		Date	Activity
16	Regeneration		
	Lecture on Nursery Practices	1	Silviculture
	Visit Catalina Nursery		Timber Marking Test at Luquillo
17	Regeneration		Return to Río Piedras
	Lectures on Tree Planting	4	Forest Mensuration
18	Regeneration		Lecture on Forest Mensuration
	Field Study of Forest Plantations Toro Negro		Mensuration Practices and Equipment
			Lecture on Timber Cruising
19	Return to Río Piedras		
		5	Forest Mensuration
21	Regeneration		Practice Cruising at Luquillo

6	Forest Mensuration Practice Cruising at Luquillo		Lecture on Forest Research Tree Growth Measurements at Luquillo
7	Forest Mensuration Practice Cruising at Luquillo Return to Río Piedras	26	Forest Research Analysis of Tree Growth Measurements at Luquillo
8	Holiday - Good Friday		
11	Forest Mensuration Tree Measurements for Volume Determination at Carite Return to Río Piedras	27	Forest Research Study Growth Factors at Lu- quillo Research Procedures
12	Forest Mensuration Computation of Tree Volumes Construction of Volume Tables	28	Forest Research Study of Regeneration Tests at Cambalache Training Films
13	Forest Mensuration Compilation of Cruise Data	29	Resumé of Previous Two Months Work Review Forestry Practices Afternoon Open
14	Forest Mensuration Compilation of Cruise Data Afternoon Open - Pan American Day		
15	Forest Mensuration Summarize Cruise Data	Date	Program for May Activity
18	Wood Utilization Lecture on Wood Utilization Mechanical and Physical Proper- ties of wood	2	Forest Resources Field Trip See Fish Hatchery at Maricao See Municipal Water System at Maricao
19	Wood Utilization Visit Small Sawmill in Carolina Machining Tests Training Films	3	Continue Forest Resources Field Trip See Maricao Forest and Re- creation Area See Guánica Forest and Wildlife Refuge See Guayabal Irrigation Reser- voir
20	Wood Utilization Air Seasoning of Lumber Visit Furniture Plant Visit Paper Mill	4	Continue Forest Resources Field Trip See Forest Farming Demonstra- tion at Toro Negro Description of Caonillas Water- shed Conservation Program See Dos Bocas Hydroelectric plant
21	Wood Utilization Lecture on Woodworking Machines Lecture on Wood Preservation Machining Tests	5	Policy and Organization of the U.S.F.S. Programs and Policies Administrative Management Formal Welcome Ceremony
22	Wood Utilization Complete Tests Begun April 18 Make Personal Memento Resumé on Wood Utilization Training Films		
25	Forest Research		

6	Program Revision Economic Planning and Evaluation of Forestry Discussion of Forest Economics Forest Policy in Central America	14	Introduction of Exotics Mahogany Regeneration of Dry Regions
7	Industrial Potentialities of Central American Forests Tropical Raw Pulp and Paper Ma- terials	16	Forestry Legislation Lecture on Forest Laws
9	Public Forestry Timber Management Range Management Watershed Management Fire Control	17, 18 and 19	Round Table Discussion of Fores- try Problems Individual Presentation by Countries Represented
10	Public Forestry Information and Education Forest Recreation Safety Forest Engineering Forest Inventories and Aerial Photography Regeneration with Taungya Training Films	20	New Group - Forest Research Old Group - Research Planning Conversion of Unman- aged Stands Plotless Cruising
11	Public Forest Administration See Administration of Public Forests at Luquillo	21	Old Group - Logging New Group - Plotless Cruising Intermediate Cuttings
12	Private Forestry - Panel Discus- sion on Public Aids to Private Fo- restry State and Private Extension Service Technical Assistance Flood Prevention Program Agricultural Conservation Pro- gram	23	Allied Agricultural Programs Visit Soil Conservation District at Corozal
13	Private Forestry Trip to San Lo- renzo	24	Allied Agricultural Programs Visit Agricultural Extension District at Arecibo
		25	Allied Agricultural Programs Visit Federal Agric. Experi- ment Station at Mayaguez Visit College of Agriculture at Mayaguez
		26	Allied Agricultural Programs Visit Lajas Sub-Station Return to Río Piedras
		27	Termination of Course Resumé Banquet

APPENDIX B

**Instruction Offered by Agencies other than
the Tropical Forest Research Center
of the Forest Service**

Agency	Field of Instruction
International	
Food and Agriculture Organization of the United Nations	Forest policy Forest utilization Forest mensuration Forest management
Caribbean Commission	Forest utilization
United States Government	
Foreign Operations Administration	Forest legislation Forest policy Forest economics
Forest Service (Washington Office)	Dendrology Ecology Public forestry
Soil Conservation Service	Private forestry Soil conservation
Virgin Islands Corporation	Public forestry Private forestry Silviculture
Federal Agricultural Experiment Station	Agricultural research
Agricultural Stabilization and Conservation	Private forestry
Commonwealth of Puerto Rico	
Department of State	Orientation
Industrial Development Company	Orientation
Department of Instruction	Orientation
Department of Agriculture and Commerce	Forest regeneration
Div. of Forests, Fisheries and Wildlife	Forest utilization
	Public forestry
	Forest resources - wildlife
	Private forestry
Agricultural Extension Service	Private forestry
	Agricultural extension
Water Resources Authority	Forest resources - water
Aqueduct and Sewer Service	Forest resources - water
Agricultural Experiment Station	Agricultural research
College of Agriculture	Agricultural education

APPENDIX C

List of Printed and Mimeographed Material Distributed to Trainees

Converting Factors and Tables of Equivalents used in Forestry.

Shortcuts for Cruisers and Scalers.

Text and Charts Organization of the U. S. Forest Service.

Rules for Cutting

Steps in the Development of a research Program with Outlines for Analyses, Study Plans, Reports, etc.

Timber Species of the Tropical Lowland Formations of Northern Tropical America.

Abstract Journal of Forestry Article on Hardwood Control

Timber Management on U. S. National Forests.

Sample Study Plan (Research).

The Silviculture and Management of Tropical Rain Forest with Special Reference to Ceylon.

Forestry in Guatemala.

Preparation of a Volume Table Using the Least Squares-Logarithmic Formula Method.

A Classification of Puerto Rican Farm Lands for Forest Planting.

Instructions for Forest Service Plant Collections.

Ornamental Trees of Puerto Rico.

An Underplanting Policy for Puerto Rico.

Notes on Tropical Dendrology.

Summary of Data Collected During Timber Cruising.

Summary of Results of Timber Marking in Field.

List of Outstanding Forestry Periodicals for Reference.

Partial List of Forestry Texts and Reference Books.

Partial List of U. S. Department of Agriculture Films Dealing with Forestry and Conservation Subjects, with description, etc.

Most Important Timber Species of Puerto Rico.

Forest Seed Policy of the U.S.D.A.

Certificados de Calidad y Origen y Hoja de envío de las Semillas.

Methods of Drawing Samples for Germination Tests.

Origen y Desarrollo del Servicio Forestal Federal.

Eucalipto en Plantaciones.

Los Bosques Exóticos.

Air Drying of Lumber.

Types of Lumber Dry Kilns.

Furnace-type Lumber Dry Kiln.

List of Dry Kiln Companies and Engineers and consultants in the United States.

Air Seasoning of Lumber at Small Mills.

List of Publications on the Seasoning of Wood.

Coating for the Prevention of End Checks in Logs and Lumber.

Cause and Prevention of Blue Stain in Wood.

Methods of Determining the Moisture Content of Wood.

Exploratory Tests on Machining and Related Properties of Fifteen Tropical American Hardwoods.

Woodworking Machines.

Machining and Related Characteristics of Southern Hardwoods.

List of Publications on Logging, Milling, and Utilization of Timber Products.

The Air Seasoning of Wood.
 Protection Against Wood-destroying Organisms.
 Methods of Determining the Specific Gravity of Wood.
 Properties of Some Bamboos Cultivated in the Western Hemisphere.
 Mechanical Properties of Brazilian Parana pine.
 Use of Bleached Cold Soda Pulps from Certain Mixtures of Latin-American Hardwoods in Newsprint.
 Control of Stain, Mold, and Decay in Green Lumber and Other Wood Products.
 Average Strength and Related Properties of Five Foreign Woods Tested at the Forest Products Laboratory.
 Marketing of Caribbean Timbers.
 Forest Policies, Law, Administration.
 Research in Forestry and Forest Products.
 Raw Materials for More Paper.
 Grazing and Forest Economy.
 Forest Abstracts Coverage List.
 Tropical Woods and Agricultural Residues as Sources of Pulp.
 1954 Forest Seed Directory.
 Planning a National Forest Inventory.
 Elements of Fire Control.
 Forest Plantation Protection Against Diseases and Insect Pests.
 World Festival of Trees.
 A Small Lumber-drying Unit Employing a Portable Crop Drier for Heat and Air Circulation.
 Sapstain Control Treatments Before or After Dressing.

Simplified Procedure for Determining Oven-dry Specific Gravity of flitches and Bolts.

Pulping of Latin American woods.

The Caribbean Forester, Vol. 12, Nos. 3 & 4

13, Nos. 1, 2 & 4

14, Nos. 1 to 4

15, Nos 1 & 2

APPENDIX D

LIST OF TRAINING FILMS SHOWN

The River
 Conservation of Fertile Soils
 This Our Land
 Raindrops and Soil Erosion
 Erosion
 Agua
 Forest Treasures
 Trees to Tame the Wind
 Smokey the Bear
 Your American Tragedy
 El Guardia Forestal
 The Small Sawmill
 Mountain Water
 Rainbow Valley
 Realm of the Wild
 Everyman's Empire
 Forest Fire Fighting in the South
 Grass and Cattle
 Lifeblood of the Land
 Operation of a Forest Nursery
 Waters of Coweet

Participants and Instructors — Tropical Forestry Short Course
Held in Puerto Rico March 1 to May 29, 1955



Standing, left to right

L. J. Cummings	— I.C.A. Panamá
F. H. Wadsworth	— U.S.F.S. Puerto Rico
A. A. M. Berenos	— Surinam
A. Cuevas López	— Mexico
L. Macías A.	— Mexico
A. Pinillos	— Guatemala
R. A. de Rosayro	— Ceylon
E. S. Molgo	— Surinam
R. F. Haussman	— U.S.F.S. Virgin Islands
I. P. Murray	— U.S.F.S. United States
J. García	— Colombia
J. Sánchez	— Colombia
J. Alviar	— Colombia
R. Garduño G.	— Mexico
C. F. Ehelebe	— I.C.A. Guatemala
L. A. Palma N.	— Nicaragua
R. Chavez	— Mexico

B. J. Huckenpahler	— U.S.F.S. Puerto Rico
C. C. Pierre-Louis	— Haiti
C. M. Mathur	— India
A. I. Iyppu	— India

Seated, Left to Right

T. Jeyadev	— India
B. S. Bhatena	— India
V. H. Alvarado	— Guatemala
J. A. Gallegos Terán	— Ecuador
F. P. Bazan	— Perú
A. Madriz	— Costa Rica
K. K. Cheong	— British Guiana
M. R. Reyes	— Philippines
C. V. K. Reddy	— India
T. N. Ly	— Vietnam
R. L. Ambroise	— Haiti

Informe Sobre el Curso Corto de Dasonomía Tropical Celebrado en Puerto Rico, Marzo 1ro. a Mayo 29, 1955

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La rápida expansión de programas bilaterales y multilaterales en el entrenamiento internacional de dasonomía ha atraído a Puerto Rico un número siempre en aumento de estudiantes. Aquellos estudiantes que llegan a Estados Unidos de países que tienen bosques tropicales y particularmente los de la América Latina, generalmente pasan una parte considerable de su entrenamiento en Puerto Rico, el único puesto de avanzada de la dasonomía tropical en los Estados Unidos de Norte América.

La experiencia demuestra que el entrenamiento individual de técnicos es menos eficiente que el entrenamiento en grupo. El entrenamiento individual requiere una inversión considerable del tiempo de los instructores por estudiante y generalmente no permite cubrir un campo amplio en el corto período generalmente designado. Como un medio para eliminar dichos problemas se organizó un curso corto temprano en 1955. Otras de las ventajas reconocidas del entrenamiento en grupo eran las posibilidades de justificar el uso de especialistas de fuera de la isla como instructores y las discusiones de mesa redonda, en las cuales los estudiantes pueden describir y discutir problemas y programas de política nacional para beneficio mutuo.

DESCRIPCION DEL CURSO

La Administración de Operaciones Extranjeras asumió el respaldo del curso reclutando la mayor parte de los estudiantes y pa-

gando un oficial de entranamiento, un líder de grupo, la mayor parte de la instrucción y los costos de viajes y dietas de los estudiantes. La Organización de las Naciones Unidas para la Agricultura y la Alimentación cooperó estrechamente y contribuyó con instructores durante parte del período, con estudiantes y material educativo. La Comisión del Caribe ayudó en el reclutamiento de tres estudiantes.

El Centro de Investigaciones Forestales Tropicales del Servicio Forestal Federal en Puerto Rico asumió la dirección del curso. En ese sentido el Centro de Investigaciones recibió la cooperación de varias agencias del Estado Libre Asociado de Puerto Rico, particularmente de la División de Bosques, Pesca y Vida Silvestre del Departamento de Agricultura y Comercio, de la Oficina de Cooperación Técnica del Departamento de Estado y del Servicio de Extensión Agrícola de la Universidad de Puerto Rico. Otras agencias federales en la isla ofrecieron su cooperación, en particular el Servicio de Conservación de Suelos del Departamento de Agricultura.

Materias Tratadas

El entrenamiento estaba orientado a satisfacer dos necesidades: (1) ofrecer información en cuanto a prácticas y técnicas a los técnicos en puestos subalternos en los Servicios Forestales y (2) suplir información sobre política, organización, administración

^{1/} Respectivamente — Líder, Centro de Investigaciones y Oficial de Entrenamiento, Centro de Investigaciones Forestales Tropicales y Líder de Grupo, Administración de Operaciones Extranjeras.

y legislación a los jefes y otros oficiales superiores. Para cubrir la primer fase se designó un período de dos meses y un mes para la segunda fase. Esta última siguió inmediatamente a la primer fase, de manera que su información sirviera de enlace y como una proyección de la información ofrecida en la

primera fase demostrando su sitio en un programa nacional. Por lo tanto el grupo subalterno asistió al curso completo de tres meses.

Las materias tratadas en el orden del programa se presentan en forma de bosquejo en la siguiente tabulación.

Materias	Días	
	Conferencias	Campo o laboratorio
Sesión en Prácticas - Marzo 1 - Abril 29		
Orientación sobre Puerto Rico, sus bosques y dasonomía	3	-
Dendrología	2-1 ₂	1-1 ₂
Ecología	1 ₂	1
Reforestación	2-1 ₂	6
Silvicultura	1	5-1 ₂
Mensuración	1-1 ₂	6-1 ₂
Utilización	1-1 ₂	3-1 ₂
Investigaciones	1	3-1 ₂
Otras materias forestales relacionadas	4	-
Subtotal	17-1 ₂	27-1 ₂
Sesión en Programas - Mayo 2 - Mayo 27		
Recursos forestales	-	3
Economía forestal	1	-
Dasonomía pública	2-1 ₂	1
Dasonomía particular	1	1
Legislación forestal	1	-
Investigación forestal	1	1
Problemas y política forestal de los países representados	3	-
Otras materias forestales relacionadas	1-1 ₂	-
Programas gubernamentales afines	-	4
Subtotal	11	10
Total	28-1 ₂	37-1 ₂

La orientación ofrecida al principio del curso fué amplia y estuvo a cargo de líderes locales en los campos de ciencias políticas, industrias, educación y agricultura. A petición de los estudiantes se incluyeron 12 materias adicionales relacionadas con la dasonomía, las que incluyeron discusiones especiales e industrias forestales, inventario forestal, fotografía aérea, repoblación bajo el sis-

tema de "taungya", introducción de especies exóticas, repoblación de regiones áridas, mensuración sin el uso de parcelas de ensayos, silvicultura de caoba, utilización de pastos, manejo de rodales naturales y explotación de bosques. Otros programas gubernamentales afines incluían los del Servicio de Extensión Agrícola, el Servicio de Conservación de Suelos, la Estación Experimental

Agrícola y el Colegio de Agricultura. Otros puntos de interés visitados incluyeron una factoría de azúcar, un enlatado de piñas y una finca donde no se utiliza la tierra (hydroponics). En el Apéndice A se presenta un itinerario día por día.

Instructores

La parte principal de la instrucción estuvo a cargo del personal del Servicio Forestal en Puerto Rico incluyendo ambas ramas de Administración e Investigación en el Servicio Forestal Federal. Dicho personal condujo la instrucción en tales materias como repoblación, silvicultura, mensuración, utilización, investigación y administración forestal pública. Sin embargo el alcance del curso fué tan amplio, que se hizo necesario reclutar instructores adicionales de otras agencias de dentro y fuera de Puerto Rico. El Apéndice B incluye una lista de las contribuciones de dichas agencias.

Estudiantes

El aviso del curso estipulaba que los candidatos para el curso completo de tres meses debían ser "oficiales subalternos en el gobierno en países tropicales, que ocupen puestos relacionados con la administración, manejo o utilización de recursos forestales o en campos muy relacionados. Se le dará preferencia a dasónomos, graduados o agrónomos que ocupen puestos en los Servicios Forestales o que posean un entrenamiento equivalente". Para cualificar para el entrenamiento durante el último mes los candidatos deberían tener una preparación equivalente y ocupar puestos de responsabilidad en los Servicios Forestales correspondientes. Debido a las limitaciones físicas se limitó el número de participantes a 20 en cada categoría. Asumimos que cada país obtendría mayor provecho del curso enviando un oficial subalterno y un oficial superior.

En total 14 estudiantes asistieron durante los primeros dos meses y un grupo adicional de 12 estudiantes durante el último mes. De este último grupo siete estudiantes

estaban bajo los auspicios de la Administración de Operaciones Extranjeras, FOA (tres de los cuales fueron reclutados por la Comisión del Caribe) y el resto por la Organización de las Naciones Unidas para la Agricultura y la Alimentación, FAO. En la siguiente tabulación ofrecemos el nombre de cada estudiante, su país de origen y el período de entrenamiento.

Entrenamiento de Tres Meses

Boman S. Bhatena	India
Roberto Chávez	México
Jorge A. Gallegos Terán	Ecuador
Julio García	Colombia
Alapatt I. Iyppu	India
T. Jeyadev	India
Thi Nghia Ly	Viet-Nam
Arnoldo Madriz	Costa Rica
C. M. Mathur	India
Luis A. Palma N.	Nicaragua
Claude C. Pierre-Louis	Haití
C. V. K. Reddy	India
Martin R. Reyes	Islas Filipinas
James Sánchez	Colombia

Entrenamiento de un Mes

Virgilio H. Alvarado--	Guatemala
Jairo Alviar	Colombia
Rene L. Ambroise	Haití
Flavio P. Bazán	Perú
Albert A. M. Berenos	Surinam (Guayana Holandesa)
Kenneth K. Cheong	Guayana Británica
Armando Cuevas López	México
Roberto C. Garduño	México
Luis A. Macías	México
Eduard S. Molgo	Surinam
Alfredo Pinillos	Guatemala
R. A. de Rosayro	Ceilán

Facilidades

Las conferencias se condujeron en la biblioteca de la oficina central del Servicio Forestal. El laboratorio de maderas, el vivero

y el herbario de la oficina central también se utilizaron. El grupo incluía estudiantes de habla inglesa y española lo cual hizo necesario las traducciones. La traducción de las conferencias estuvo a cargo de miembros del Servicio Forestal. La traducción fué generalmente más breve que la presentación originalmente y no fué necesaria en el trabajo de campo. La información más importante se preparó en forma de mimeógrafo en ambos idiomas. El Apéndice C incluye una lista del material distribuido a los estudiantes y en el Apéndice D se enumeran las películas educativas.

La mayor parte del trabajo de campo se llevó a cabo en terrenos públicos dentro de dos bosques federales y siete bosques del Estado Libre Asociado. Los estudiantes se alojaron temporalmente en edificios localizados en los bosques de Luquillo, Toro Negro, Río Abajo y Maricao. En total los estudiantes pasaron 12 noches en el campo. La transportación se hizo en carros estilo turismo y en camionetas, algunos de los cuales se arrendaron por día. Durante los tres meses se cubrió una distancia total de 2,700 millas casi toda sobre carreteras empedradas. Como un 30 por ciento del tiempo transcurrido en el campo equivalente a un 16 por ciento del tiempo total se utilizó en las travesías.

Facilidades de Alojamiento

El deseo de asegurar alojamiento a un precio razonable y localizar los estudiantes cerca de la oficina central del Servicio Forestal y en contacto entre sí, llegó a organizar una cooperativa de acuerdo con y financiada por los estudiantes. Dicha cooperativa, administrada por el líder del grupo arrendó apartamentos adyacentes en un gran edificio de apartamentos. Los profesores y todos menos tres de los estudiantes participaron en este arreglo. Cada apartamento albergaba un promedio de cinco hombres.

La cooperativa también proveía las comidas y se alquiló un apartamento extra para una cocina comedor. Se adquirieron los servicios de un cocinero y su ayudante, comprándose los comestibles. Cuando se hacía

necesario se transportaba al campo el cocinero, equipo de cocina, comestibles y ropa de cama junto con los estudiantes. En los fines de semana el cocinero estaba libre y muchos de los estudiantes preparaban sus comidas en sus apartamentos mientras que otros comían en los restaurantes cercanos. Por acuerdo mutuo el fondo cooperativo también se utilizó para financiar otros proyectos tales como comidas especiales, banquetes y algunos viajes.

Actividades Extracurriculares

Para beneficio de los estudiantes se organizó un número de actividades fuera del curso. Esto incluyó seis comidas de las cuales se ofrecieron tres en casas privadas; cuatro fiestas coctel, dos recepciones, dos bailes, dos excursiones a sitios históricos, dos viajes a la playa, un concierto, una visita a un área recreativa, un viaje a la bahía fosforescente, asistencia a la inauguración de la Conferencia de las Indias Occidentales y del Aeropuerto Internacional, y actividades religiosas. Varias de esas actividades fueron organizadas por la Oficina de Cooperación Técnica del Departamento de Estado del Estado Libre Asociado.

Las facilidades de un comedor cooperativo hizo posible que el grupo pudiera invitar sus amigos a comer. Por todo unas 50 personas incluyendo varios oficiales prominentes, fueron invitados. Personas particulares también fueron invitadas a ver las películas exhibidas en el comedor por la noche.

Al planear el programa del curso se hizo un esfuerzo para integrar actividades culturales, estéticas y recreativas en oportunidades apropiadas y sobre todo para mostrar donde fuera posible cómo estas actividades estaban relacionadas a los programas forestales de Puerto Rico proveyéndole experiencias inolvidables a los participantes. Cuantas veces fué posible se hicieron arreglos para almorzar y pernoctar en sitios que ofrecían excelentes ejemplos característicos de Puerto Rico.

LOGROS PRINCIPALES

Los logros principales del curso parecen poderse clasificar dentro de tres categorías generales: (1) la diseminación de información en dasonomía tropical, (2) los contactos profesionales de los estudiantes y (3) comprensión más amplia de los conocimientos generales.

Los instructores dieron demostraciones y supervisaron la participación de los estudiantes en ciertos tipos de trabajos forestales y además le describieron otras prácticas, técnicas y ángulos que no eran fáciles de demostrar localmente. Sobre todo se les mostró todos los resultados más importantes de 30 años de actividades forestales y de otras actividades análogas en Puerto Rico. Conocieron las especies forestales más importantes, los distintos tipos forestales y los resultados de repoblación de tierras desnudas, siembras de caoba bajo un dosel, mejoramiento del bosque natural, y los efectos de un manejo y administración forestal ordenado. También se les enseñó cómo preparar muestras para pruebas de madera y visitaron una fábrica de muebles, una fábrica de papel y una fábrica de cartón para envases e hicieron observaciones de los métodos y prácticas usadas localmente en los programas de conservación de suelos y extensión, investigación y educación agrícolas.

Además de observar las demostraciones, los estudiantes participaron en un número de proyectos forestales. Marcaron árboles para entresaque en una plantación de teca y observaron cómo se realizaba el trabajo, marcaron árboles para una corta de mejora en un bosque pluvial mixto, prepararon una tabla de volumen sencillo para eucalipto, llevaron a cabo un inventario de un 10 por ciento en unas 335 acres de bosque pluvial y calcularon el volumen de madera propia para muebles, construcciones, postes, y combustible determinando a la vez el volumen que debería cortarse para mejorar el rodal. Además determinaron la rapidez de crecimiento durante los últimos 12 años

para 50 especies de árboles en el bosque pluvial. En los estudios de maderas le dieron tratamiento preservativo en contra de hongos y apilaron la madera para secamiento al aire. Determinaron el peso específico, la merma o disminución de volumen y el contenido de humedad de la madera y usaron maquinaria para fabricar pequeños objetos.

Los instructores ofrecieron demostraciones en muchos aspectos adicionales de dasonomía que no eran fáciles de mostrar en el salón de clases. Entre éstos incluían las pruebas de semillas, prácticas de viveros, métodos de inventarios sin el uso de parcelas de ensayos, el planeamiento y diseño de experimentos, el sistema de parceleros, la organización del Servicio Forestal de Estados Unidos y la política y las prácticas de la administración forestal de ese país.

No todo el entrenamiento provino de los instructores. Los estudiantes contribuyeron con mucha información de interés común en las discusiones de mesa redonda y en discusiones fuera del salón de clases. En una sesión de tres días se le dió una oportunidad a cada estudiante para describir la situación forestal y los problemas de su país. Esos puntos de vista fueron luego discutidos por el grupo entero. Además los estudiantes ofrecieron conferencias y dirigieron la instrucción en materias de interés especial como por ejemplo: la repoblación por medio del sistema de taungya, la repoblación de áreas secas, la introducción de especies exóticas y los problemas de pastoreo.

El entrenamiento fué muy efectivo en unir los estudiantes. Al vivir juntos, incluyendo muchos de los instructores, las diferencias de rango no crearon fricción alguna. Según avanzaba el curso se daban mejor cuenta de la naturaleza de sus respectivos problemas, muchos de los cuales son comunes para la América Latina. Como consecuencia al terminarse el curso expresaron sus deseos de mantener los contactos y de reunirse periódicamente en el futuro para discutir francamente sus problemas.

El curso también contribuyó a ampliar los conocimientos generales de los estudiantes, particularmente de aquellos del Viejo Mundo. La orientación ofrecida le clarificó el status de Puerto Rico en sus relaciones políticas con Estados Unidos y describió el gobierno y el progreso de la isla en educación, agricultura e industrialización. Además los estudiantes viajaron a distintas partes de la isla y conocieron líderes locales y se enteraron de nuestro sistema de vida a través de numerosos contactos sociales. Además se enteraron de cómo viven los habitantes de los otros trece países representados por sus compañeros con los cuales estuvieron íntimamente relacionados.

Una medida adicional del éxito del curso la constituyó la seguridad y el record de salud de los estudiantes e instructores. El curso incluyó unos 1,750 hombres-días, incluyendo el tiempo de estudiantes y se viajó más de 12,000 millas en automóvil, sin embargo no ocurrió ningún accidente. Solamente se perdió un hombre-día por enfermedad.

APENDICE A

Programa para el mes de Marzo

Fecha	Actividad
1	Arreglos de alojamiento, etc.
2	Discurso de bienvenida
3	Charla sobre la administración del curso
	Charla sobre la educación en Puerto Rico
	Charla sobre el desarrollo económico en P. R.
	Charla sobre Orientación general
	Charla sobre la agricultura en Puerto Rico
4	Conferencias sobre problemas forestales en P. R.
	Tierras
	Protección de cuencas
	Abastecimiento de maderas
	Utilización

	Vida silvestre
	Recreo
	Conferencias sobre el desarrollo de la dasonomía en Puerto Rico
	Antes de 1900
	Historia del Servicio Forestal Federal en P. R.
	División de Bosques, Pesca y Vida Silvestre
	Servicio de Extensión
	Servicio de Conservación de Suelos
5	Recepción para estudiantes
7	Dendrología
	Conferencia sobre nomenclatura y clasificación de árboles
	Sesión de laboratorio en terminología botánica
8	Dendrología
	Identificación de árboles - uso de claves
	Conferencias sobre ecología
9	Dendrología y ecología
	Excursión al bosque de Cambalache
10	Dendrología
	Conferencia sobre las familias importantes de esencias forestales
	Herborización y preparación del herbario
11	Dendrología y ecología
	Excursión a las montañas de Luquillo y El Yunque
12	Dendrología
	Examen y conferencia
14	Reproducción
	Conferencia
	Prueba con semillas en el vivero de Río Piedras
15	Reforestación
	Conferencia sobre prácticas de vivero
	Orientación y desarrollo político de Puerto Rico
	Reforestación

Conferencia sobre práctica de vivero		Programa para Abril	
Visita al vivero de Catalina		Fecha	Actividad
17	Reforestación	1	Silvicultura
	Conferencia sobre siembras forestales		Prueba de marcadura de madera en el bosque de Luquillo
			Regreso a Río Piedras
18	Reforestación	4	Mensuración
	Examen de plantaciones forestales en Toro Negro		Conferencia sobre mensuración
			Prácticas y equipo de mensuración
19	Regreso a Río Piedras		Conferencia sobre inventario de maderas
21	Reforestación		
	Examen de plantaciones forestales en Guajataca	5	Mensuración
			Práctica de trabajo en inventario en Luquillo
22	Reforestación		
	Examen de plantaciones forestales en Luquillo	6	Mensuración
			Práctica de trabajo en inventario en Luquillo
23	Reforestación		
	Examen de plantaciones forestales en Carite	7	Mensuración
			Práctica de trabajo en inventario en Luquillo
24	Reforestación		
	Resumen		Regreso a Río Piedras
	Silvicultura	8	Día feriado - Viernes Santo
	Conferencia sobre elementos de la silvicultura y silvicultura	11	Mensuración
	Conferencia sobre silvicultura tropical		Medición de árboles para determinar el volumen en el bosque de Carite
25	Silvicultura		Regreso a Río Piedras
	Marcar plantación de teca para entresaque en Río Abajo	12	Mensuración
	Estudiar aclareos de teca y caoba		Cálculo de volumen
		13	Cálculo de tablas de volumen
	Estudiar plantación de teca después de aclararse		Mensuración
	Regreso a Río Piedras	14	Recopilar datos del inventario
28	Silvicultura		Mensuración
	Estudiar aclareos en manglares en Aguirre	15	Recopilar datos del inventario
			Tarde libre - Día Panamericano
29	Silvicultura	18	Mensuración
	Observar efectos de cortas de madera en el bosque de Luquillo		Resumen de datos del inventario
			Utilización de maderas
31	Silvicultura		Conferencia sobre utilización de maderas
	Practicar marcadura de madera en el bosque de Luquillo	19	Propiedad física y mecánica de la madera
			Utilización de maderas
			Visita al aserradero pequeño en Carolina

	Pruebas de máquinas		Visita al vivero de peces de Maricao
	Películas de entrenamiento		Visita al Acueducto Municipal
20	Utilización de maderas		Viaje al bosque de Maricao
	Secado de maderas al aire	3	Viaje al campo (recursos forestales)
	Visita a la fábrica de muebles		Visita al bosque de Maricao y su área de recreo
	Visita a la fábrica de papel		Visita al bosque y refugio de pájaros de Guánica
21	Utilización de maderas		Visita a la presa de riego de Guayabal
	Conferencia sobre máquinas para trabajo en maderas		
	Conferencia sobre preservación de maderas		
	Pruebas de máquinas	4	Viaje al campo (recursos forestales)
22	Utilización de maderas		Demostración de cultivos agrícolas en el área forestal
	Pruebas completas principiadas		Descripción del programa de conservación de la cuenca de Caonillas
	Fabricar objeto como recuerdo		Visita a la planta hidroeléctrica de Dos Bocas
	Resumen en utilización de maderas		
	Películas de entrenamiento		
25	Investigación forestal		Política y organización del Servicio Forestal de Estados Unidos
	Conferencia sobre investigación forestal	5	Programas y políticas
	Medición de crecimiento en árboles en el bosque de Luquillo		Administración
26	Investigación forestal		Bienvenida
	Análisis de medidas de crecimiento tomadas en Luquillo	6	Revisión del programa
	Análisis de los factores de crecimiento.		Planificación económica y evaluación de la dasonomía
27	Investigación forestal		Discusión sobre economía forestal
	Factores de crecimiento en el bosque de Luquillo		Política forestal en Centro-América
	Procedimientos usados en investigación	7	Potencialidades industriales de los bosques de Centro-América
28	Investigación forestal		Materia prima tropical para la fabricación de papel
	Estudios de pruebas de repoblación en Cambalache	9	Dasonomía pública
	Películas de entrenamiento		Manejo de árboles maderables
29	Resumen del trabajo de los dos meses anteriores		Manejo de pastos
	Repaso de prácticas forestales		Manejo de cuencas hidrográficas
	Tarde libre	10	Control de incendios

Programa para el Mes de Mayo

Fecha	Actividad	
2	Viaje al campo (Recursos Forestales)	Dasonomía pública
		Información y educación
		Recreación forestal
		Seguridad
		Ingeniería forestal
		Inventarios forestales y fotografía aérea
		Regeneración con "Taungya"

11	Administración de bosques públicos Ver administración de bosques públicos en Luquillo	20	Grupo nuevo - Investigación forestal Primer grupo - Planificación de in- vestigación Problemas especiales de pastoreo Conversión de rodales que no han sido manejados Inventario sin cuarteles de ensayo Cortas de mejora
12	Dasonomía particular - Discusión sobre la contribución a la Dasono- mía en terrenos particulares Estatal y particular Servicio de Extensión Asistencia técnica Programa de prevención de inundaciones Programa de conservación agri- cola	21	Corte y transporte de trozas (primer grupo) Crecimiento de árboles Grupo nuevo - Inventario sin cuar- teles de ensayo Cortas de mejora
13	Viaje a fincas particulares	23	Visita al Distrito de Conservación de Suelos
14	Grupo A - Introducción de espe- cies exóticas Grupo B - Caoba Grupos A y B - Regeneración de regiones secas	24	Visita al Distrito de Extensión Agrícola
16	Legislación forestal Conferencia sobre leyes fores- tales	25	Programas agrícolas relacionados Visita a la Estación Experimen- tal Agrícola Federal en Maya- güez Visita al Colegio de Agricultura, Mayagüez
17, 18, 19	Discusión de mesa redonda sobre problemas forestales Presentación individual de los paí- ses representados	26	Programas agrícolas relacionados Visita a la Subestación de Lajas Visita al laboratorio marino Regreso a Río Piedras
		27	Resumen y fin del curso

APENDICE B

**Instrucción Contribuida por Agencias Fuera del Centro de Investigaciones Forestales
Tropicales del Servicio Forestal**

Agencia	Campo de Instrucción
Internacional	
Organización de las Naciones Unidas para la Agricultura y la Alimentación	Política forestal Utilización Mensuración Manejo Forestal
Comisión del Caribe	Utilización
Gobierno de Estados Unidos	
Administración de Operaciones Extranjeras	Legislación forestal Política forestal Economía forestal
Servicio Forestal (Oficina de Wash.)	Dendrología Ecología Dasonomía pública
Servicio de Conservación de Suelos	Dasonomía particular Conservación de suelos
Corporación de Islas Vírgenes	Dasonomía pública Dasonomía particular Silvicultura
Estación Experimental Agrícola Federal	Investigación forestal
Conservación y Estabilización Agrícola	Dasonomía particular
Estado Libre Asociado de Puerto Rico	
Departamento de Estado	Orientación
Compañía de Fomento Industrial	Orientación
Departamento de Instrucción	Orientación
Departamento de Agricultura y Comercio	Orientación
Div. de Bosques, Pesca y Vida Silvestre	Repoblación forestal Utilización Dasonomía pública Recursos forestales - Vida Silvestre
Servicio de Extensión Agrícola	Dasonomía particular Dasonomía particular Extensión agrícola
Autoridad de Fuentes Fluviales	Recursos forestales
Servicio de Acueductos y Alcantarillados	Recursos forestales
Estación Experimental Agrícola	Investigación agrícola
Colegio de Agricultura	Educación agrícola

APENDICE C

Lista de Material Impreso o Mimeografiado

Distribuido a los Estudiantes

Factores de Conversión y Tablas de Medidas Equivalentes usadas en la Dasonomía.
 Métodos breves para el Uso de Mensuradores y Cubicadores.
 Textos y Cartas de Organización del Servicio Forestal de Estados Unidos de N. A.
 Reglas para la corta.
 Desarrollo de un Programa de Investigación Incluyendo Bosquejos de análisis, planes de estudio, informes, etc.
 Especies Madereras de las Formaciones Tropicales de Tierras Bajas en el Norte de Sur América.
 Compendio del Artículo Sobre Eliminación de Especies Indeseables de Hojas Anchas Publicado en el "Journal of Forestry".
 Manejo Forestal en los Bosques Nacionales de Estados Unidos de N. A.
 Plan de Estudio de Muestreo (Investigación).
 La Silvicultura y Manejo del Bosque Pluvial Tropical con Referencia Especial a Ceilán.
 La Dasonomía en Guatemala.
 Preparación de una Tabla de Volumen Utilizando el Método de la Fórmula Logarítmica de los Mínimos Cuadrados.
 Clasificación de los Terrenos Propios para Reforestación en las Fincas de Puerto Rico.
 Instrucciones del Servicio Forestal Sobre Herborización.
 Arboles Ornamentales de Puerto Rico.
 Política Sobre Siembras Bajo Rodales en Puerto Rico.
 Notas Sobre Dendrología Tropical.
 Sumario de los Resultados de Marcación de Maderas en el Monte.
 Sumario de los Datos Obtenidos en la Mensuración de Bosques.
 Lista para Referencias de Revistas Sobre-salientes Sobre Dasonomía.

Lista Parcial de Textos de Dasonomía y Libros de Referencias.
 Lista Parcial de Películas del Departamento de Agricultura Federal Sobre Asuntos de Dasonomía y Conservación.
 Especies Madereras más Importantes de de Puerto Rico.
 Política del Departamento de Agricultura de Estados Unidos de N. A. Sobre Semillas Forestales.
 Certificado de Calidad y de Origen y Hoja de Envío de las Semillas.
 Métodos para Obtener Muestras para Pruebas de Germinación.
 Origen y Desarrollo del Servicio Forestal Federal.
 Eucalipto en Plantaciones.
 Los Bosques Exóticos.
 Secado de Madera al Aire.
 Tipo de Estufa para Secar Madera.
 Estufa para Secar Madera por el Sistema de Horno.
 Lista de Compañías, Ingenieros y Consultores Relacionados con el secado de la Madera en los Estados Unidos de N. A.
 Secado de la Madera al Aire en los Aserradores Pequeños.
 Lista de Publicaciones Sobre el Secado de la Madera.
 Revestimiento para Evitar las Rajaduras en los Extremos de las Trozas de la Madera.
 Causas y Medidas para Evitar la Descoloración Azul de la Madera.
 Métodos para Determinar el Contenido de Humedad de la Madera.
 Pruebas Exploratorias de la Adaptabilidad de Trabajos de Máquina y otras Propiedades Relacionadas de 15 Maderas Tropicales de Hojas Anchas.
 Máquinas para Trabajo en Madera.
 Adaptabilidad a Trabajos de Máquina y Otras Características Relacionadas de Especies de Hojas Anchas Meridionales.
 Lista de Publicaciones Sobre Explotación, Aserrado y Utilización de Productos Madereros.
 Secamiento al Aire de la Madera.
 Protección en Contra de los Organismos Destructores de la Madera.

Propiedades de Algunas Especies de Bambú Cultivadas en el Hemisferio Occidental.

Propiedades Mecánicas del Pino Brasileiro Paraná.

Uso de Ciertas Mezclas de Pulpa Derivadas de Especies de Hojas Anchas de Latinoamérica y Blanqueadas por el Procedimiento de Soda Fría en la Fabricación de Papel de Periódico.

Dominio de Descoloración, Moho y Podredumbre en Madera Verde y Otros Productos Maderables.

Resistencia Promedio y Propiedades Relacionadas de 5 Maderas Extranjeras Probadas en el Laboratorio de Productos Forestales.

Mercadeo de Maderas del Caribe.
Política, Ley y Administración Forestal.
Investigaciones en Dasonomía y Productos Forestales.

Materia Prima para Fabricar más Papel.
Pastoreo y Economía Forestal.

Lista de Compendios de Publicaciones Forestales.

Maderas Tropicales y Residuos Agrícolas como una Fuente de Pulpa.

Directorio de Semillas Forestales para 1954.

Cómo Planear el Inventario Forestal Nacional.

Elementos de Dominio de Incendios.
Protección de las Plantaciones Forestales en Contra de Enfermedades y Plagas de Insectos.

Festival Mundial del Arbol.

Una Pequeña Unidad de Secar Madera Utilizando un Secador Portátil y Circulación de Aire.

Dominio de la Descoloración de la Albura Antes y Después de la Cura.

Procedimientos Simplificados para Determinar el Peso Específico de la Madera de Piezas Gruesas y Trozas Cortas Secadas al Horno.

Fabricación de Pulpa Utilizando Maderas Latino-Americanas.

El Caribbean Forester, Vol. 12, Nos. 3 y 4

Vol. 13, Nos. 1, 2, y 4

Vol. 14, Nos. 1 y 4

Vol. 15, Nos. 1 y 2

APENDICE D

Lista de Películas Educativas Mostradas

El Río

Conservación de Suelos Fértiles

Esta Nuestra Tierra

Gotas de Lluvia y Erosión de Suelos

Erosión

Agua

Tesoros Forestales

Arboles para Dominar el Viento

El Oso, Smokey

Su Tragedia Americana

El Guardia Forestal

El Pequeño Aserradero

Agua de la Montaña

El Valle del Arco Iris

El Reino de lo Salvaje

El Imperio de Cada Hombre

Dominio de Incendios Forestales en el Sur

Pastos y Ganado

Sangre Vital de la Tierra

Funcionamiento de un Vivero Forestal

Aguas de Coweeta

Trees of Mona Island

Elbert L. Little Jr.

U. S. Forest Service

Washington, D. C.

Mona Island, belonging to Puerto Rico, has been visited by various biologists who search for the peculiar, local plants and animals often present on such isolated small islands. In 1915 N. L. Britton (2) published a list of the plants of Mona Island. Botanists visiting this locality subsequently have not recorded additional species. As collections by the author in 1954 and 1955 contain some additions, it may be appropriate to prepare a new list of the trees and large shrubs of the island, totaling 74 native species, of which 12 were not in Britton's list, and 26 introduced species, mostly cultivated and among them 22 additions. Also, a new analysis of the relationships of the flora can be made from the detailed information on distribution now available.

DESCRIPTIVE BACKGROUND

General information about Mona Island has been published by Wadsworth (8) and by Wadsworth and Gilormini (9). This semi-arid and almost uninhabited island is located in Longitude 67°55' West and Latitude 18°05' North, in Mona Passage, about midway between Puerto Rico and Hispaniola, both of which are visible (from high places on the island) on a clear day. Mona Island is about 42 miles directly west from the town of Cabo Rojo, Puerto Rico and 47 miles slightly south of west from Mayagüez. It is less than 40 miles east-southeast of Point Espada, Dominican Republic. The name, of Indian origin, is from the old name of the island, Amoná.

In Mona Passage, which has a depth varying between 1,200 and 3,800 feet, are two smaller uninhabited Puerto Rican islands. Three miles north-northwest of Mona Island is Monito, which has an area of about 100 acres, and 30 miles northeast is Desecheo. The latter, a rounded island less than 1 square mile

in area with a peak 600 feet high, is only 13 miles west of Punta Jigüero, the westernmost point of Puerto Rico. About 40 miles west of Mona Island, adjacent to Hispaniola, is Saona, a larger island with similar topography.

Geology

A summary of the geological history will serve as a background for the study of the relationships of the flora. Brief references to the geology of Mona Island have been made by Meyerhoff (6), Schubert (7), and others. The volcanic Antillean Mountains occupying Puerto Rico in the Cretaceous extended into Mona Passage, as shown by the deformed strata on Desecheo, but may have been broader and lower toward Mona. Then following submergence, Puerto Rico and the Virgin Islands have been land continuously since Eocene and have been joined to at least the northeastern part of Hispaniola until Pleistocene. There have also been connections with Cuba and Jamaica and in lower Eocene, lower Oligocene, and lower Pliocene with Honduras and Nicaragua in Central America. Shallow seas occupied the present northern and southern lowland plains of Puerto Rico in the Eocene and from middle Oligocene to middle Miocene.

With uplift in the Oligocene epoch, Hispaniola, Puerto Rico, and the Virgin Islands together formed a single island, including Mona, almost as long and narrow as Cuba now is. In the Miocene there was some inundation, though Hispaniola, Puerto Rico, and Virgin Islands remained connected by slender tongues of land. At that time limestone strata equivalent to the Ponce limestone of southwestern Puerto Rico were deposited where Mona now rises. The present geography was formed with uplifts in late Miocene and Pliocene, when there emerged the outcrop of which

Mona Island is a part, and with erosion, fracturing, and block-faulting in upper Pliocene and Pleistocene. As faulted blocks subsided to the sea bottom, the present islands became separate and were uplifted more. The blocks now forming Mona and Desecheo remained emergent as remnants while adjacent blocks sank to depths, developing Mona Passage as a cross channel.

In recent time since the end of the last ice sheet of the Pleistocene glacial periods, there has been a rise in ocean levels of the world as much as 200 feet caused by melting of the ice. Kulp, Feely, and Tryon (5), using the carbon-14 method, dated as about 11,500 years old juniper wood from forests in Bermuda now submerged at depths of 20-50 feet. From this and other lines of evidence, they placed the beginning of the retreat of the last ice sheet as only about 11,000 years ago. At that relatively recent date, islands now surrounded by shallow seas were connected, for example, Cuba and Isle of Pines, and Key West with the other Florida Keys and the Florida mainland. The shore line of Mona Island in a deeper channel probably was not greatly affected. However, Mona Island has decreased in area perhaps as much as half of the original faulted block, owing to rapid wave erosion on the northern and eastern sides.

It is important in the study of plant distribution to note the geological evidence of past land connections between the Greater

Antilles and the continent. Besides the land bridge through Jamaica and Cayman Islands to Honduras and Nicaragua already mentioned, western Cuba has been joined also with the Yucatán peninsula. However, the Greater Antilles apparently never were connected with southern Florida, which instead has been an island also during much of its history. Likewise, the Greater Antilles and Lesser Antilles (except the southernmost) have not been connected with South America. However, the South American continent probably has extended northward about 100 miles nearer than now, continuous with present islands on the continental shelf, such as Curacao, Margarita, and Trinidad.

Physiography

As to shape, Mona Island is roughly like a bean, almost 7 miles long from east to west and more than 4 miles in greatest width, with a slightly concave northern shoreline. Its area is about 21 square miles or 13,658 acres.

The island is a nearly flat block of massive bluish limestone of Miocene age, at least in part. Its surface is a nearly level plateau of more than 13,000 acres mostly 125-200 feet elevation, and 272 feet at the highest point. On three sides precipitous cliffs rise from the sea with undercut bases and caves (See Fig. 1). Near the eastern end of the plateau is Mona Island lighthouse, maintained by the U. S. Coast Guard.



Fig. 1.—The precipitous east coast of Mona Island showing xerophytic vegetation on shallow soil exposed to the winds.

Coastal plains of sandy shores and sands up to 25 feet above sea level comprise 6 percent (900 acres) of the island's area. They are separated from the plateau by cliffs with rocky slopes and talus blocks below. Nearly all the coastal plain is on the southwest and protected shore, where the greatest width is more than $1\frac{1}{2}$ mile. Former settlements were located at Sardinera, at the northwest point of the coastal plain, and at Uvero on the southeast end. On the southeast coast is a narrow beach known as Playa de los Pájaros (Beach of the Birds), where a wharf to serve the lighthouse has been constructed.

Valleys and permanent surface water are absent. On the plateau are shallow limestone sinks or "bajuras", where runoff water collects after rains. Among the largest are Bajura de los Cerezos (Sink of the Cherry trees), slightly west of the center of the island, and in the eastern part, Cuevas del Centro (Caves of the Center) and El Corral (the Corral), which is bordered by cliffs. Water percolates downward to great depths in the porous limestone and has formed numerous caves.

Climate

The climate of Mona is hot and semi-arid, similar to that of southwestern Puerto Rico though the rainfall is less seasonal. Many small islands of low elevation in the West Indies, such as the Bahamas, probably have a comparable, somewhat dry tropical climate. Weather records have been kept since 1919 at Mona Island lighthouse (173 feet above sea level), which is a cooperative station of the U. S. Weather Bureau. Average annual precipitation at the lighthouse is about 38 inches, lowest from January to March. Temperatures are high, averaging about 80°F with daily maxima above 90°F much of the year. Strong prevailing east-northeast winds have a desiccating effect on the vegetation in the eastern part of the plateau.

Soil

Much of the plateau is covered with bare jagged ("dogtooth") limestone outcrops, but

in places there is a stony clay soil up to 2 feet deep, commonly gray but also red or brown. In the depressions or limestone sinks is a reddish loam soil. On the coastal plain the deeper soil varies from sand and low shore dunes to sandy loam.

Fauna

The animal life of Mona Island is probably similar to that of dry areas in southwestern Puerto Rico. One noteworthy difference is the presence of large lizards, or iguanas (*Cyclura stegneri*) 3 to 4 feet in length, which are now absent in Puerto Rico but very closely related to a species of Hispaniola. Terrestrial mammals were absent originally though numerous bats inhabit the caves. Now, the island is overrun with several thousand wild goats which have destroyed the more palatable vegetation in some parts and in a few areas have made browse lines on the trees. There are also small numbers of domesticated hogs which have become wild. In the past, farmers introduced cattle, but agriculture and grazing have been abandoned, and cattle are gone. Feral cats and rats remain.

History

The interesting history of Mona Island has been told at length by Wadsworth (8). Indians settled here less than a thousand years ago and developed a primitive agriculture. Columbus anchored at Mona on September 24, 1494. Then for centuries the island was a haven for pirates who raided passing ships. From 1874 to 1924 a mining industry developed, and as many as 200 men were employed removing phosphate deposits and bat guano from the island's caves for shipment as fertilizer to Europe and the United States. During that period some agriculture was practiced to supply food for the miners; trees were cut for fuel and charcoal. One family remained on the island until 1943.

Previous to 1898, Mona Island was administered by the Spanish Crown. Then it was placed under the Puerto Rican Department of Interior. In 1903 the Mona Island lighthouse was erected by the U. S. Coast Guard

and a reserve of 237 acres established for it. The island became a public forest under the Puerto Rican Government in 1919. From 1937 to 1941 a camp of the Civilian Conservation Corps was stationed at Sardinera. Besides making extensive forest plantations of *Casuarina equisetifolia* and *Swietenia mahagoni* on 420 acres of the coastal plain, the men built a truck trail across the island and various foot trails and made a forest survey.

Botanical Studies

Britton (2) in 1915 published a list of 292 species of plants of Mona Island and notes on the vegetation. Besides seed plants this total included 63 species of lower plants, or cryptogams, mostly lichens and fungi, but omitted many parasitic fungi not yet determined. This list was based mainly upon collections made February 20-26, 1914, by N. L. Britton, John F. Cowell, and W. E. Hess. These men made the trip in a sloop chartered at Mayagüez, stopping first February 18-19 at the smaller island of Desecheo, where about 90 species of seed plants were found. Also, in May 1913, F. L. Stevens and W. E. Hess collected seed plants and fungi on the two islands. From these first botanical collections on Mona Island, Britton estimated the land flora of Mona, half cryptogams, to be as high as 500 species.

Several other botanists and various zoologists have visited Mona Island though without publishing additions to Britton's list. A few tree specimens were collected here in 1940 by Forest Service men. In 1944 Wadsworth and Gilormini (9) prepared a report on the forestry possibilities on the island. They concluded that the natural forests of Mona Island are very low in productivity, that the plateau will produce little wood and no sawtimber, that the coastal plain is largely suitable for higher land uses, such as farming, and that fishing and recreation might be developed.

On August 26-28, 1954, the author and F. H. Wadsworth, collected specimens of trees and large shrubs on Mona Island. The southwestern coastal plain from

Sardinera to Uvero was examined, and the distance across most of the island from Bajura de los Cerezos to the lighthouse was covered on foot. Several tree additions to Britton's list were found. On March 14-15, 1955, the author and Captain Merle L. Kuns, of the U. S. Air Force, made additional collections of trees and shrubs at El Corral and other places on the plateau as well as on the southwestern coastal plain and at Playa de los Pájaros on the southeast.

Collections of more than 80 numbers of trees and large shrubs were made on these two trips. Specimens were not collected of tree species listed by Britton but not seen in flower or fruit nor of several planted species. Determinations were made by the author at the United States National Herbarium of the U.S. National Museum, where a set of specimens was deposited and where some of the specimens of Britton, Cowell, and Hess were examined. Other sets are at the Tropical Forest Research Center, U. S. Forest Service, Río Piedras, Puerto Rico, and at Mona Island. Duplicates of most specimens are at the herbaria of the New York Botanical Garden and the Chicago Natural History Museum.

THE VEGETATION

The vegetation of Mona Island, including information from the forest survey of 1938, has been summarized by Wadsworth and Gilormini (9). To that description some notes on the common species may be added. That survey in which 118 acres (588 plots) were tallied distinguished six vegetation types with the following areas:

	Acres
Cactus brush	2,237
Brush	940
Upland forest	9,228
Central lowland forest	348
Coastal lowland forest	788
Other coastal lowlands	117
	<hr/>
	13,658

The first four types cover the plateau, and the last two the coastal plain. The cactus brush, or shrub thicket, forms a zone about a mile wide in the eastern part of the island, including the lighthouse reservation, and narrow strips on the northern and southeastern coasts. This most xeric type is found where exposure to the wind is greatest. The dominant plants are cacti and other xerophytic shrubs mostly less than 6 feet high though sometimes becoming small trees. Characteristic species include *Opuntia dillenii* (Ker.) Haw., *O. rubescens*, *Cereus hystrix*, *Cephalocereus roye-nii*, *Plumeria obtusa*, *Lantana involucrata*, and two or three species of *Croton*. This type has been overgrazed and heavily browsed by goats until its composition probably has changed somewhat. Scattered grass clumps have become scarce, though present in an enclosure, and unpalatable shrubs, especially *Croton* and *Lantana involucrata*, probably have become more abundant than in the original vegetation. A narrow strip up to $\frac{1}{4}$ mile wide forming a transition between the cactus brush and the upland forest was listed separately as brush, though not a distinct type.

The upland forest, a dry evergreen type, occupies about two-thirds of the island. It is an open woodland of many species of small trees only 12 to 20 feet tall and 4 to 12 inches in diameter at breast height, mostly small-leaf evergreens. Characteristic tree species include: *Tabebuia heterophylla*, *Metopium toxiferum*, *Bursera simaruba*, *Pisonia albida*, *Bourreria succulenta*, *Guettarda elliptica*, *Coccoloba obtusifolia*, *Krugiodendron ferreum*, and *Amyris elemifera*. In the western part of the plateau one of the commonest and largest trees is *Pisonia albida*, a deciduous species with stout whitish gray trunk and enlarged base and with soft wood.

The central lowland forest, found in six limestone sinks or "bajuras" on the plateau, is a taller, denser forest of trees 20 to 30 feet in height and to 12 inches in diameter, sometimes larger. Tree species are the same as in the upland except that the less shade-tolerant trees are absent. *Eugenia fragrams* and *Krugiodendron ferreum* are among the dominant species. *Cordia glabra* and *Psychotris nutans* are known on this island only from Bajura de los Cerezos, and *Jatropha multifida* from there and El Corral.

The coastal lowland forest, nearly all in the southwestern part of the island, originally covered the coastal plain except for shore vegetation. Now, 15 percent of the area has been cleared and farmed and is classed along with the beach vegetation as other coastal lowlands. Plantations of *Casuarina equisetifolia* and *Swietenia mahagoni* were made on 420 acres or nearly half of the coastal plain (See Fig. 2). This forest, by far the best developed on the island, once was composed of trees to 60 feet tall and 20 inches in diameter. These included the more shade-tolerant trees of the plateau with several additions, among them *Chlorophora tinctoria* and *Bucida buceras*. Among the characteristic species are: *Ficus laevigata*, *F. stahlii*, *Coccoloba diversifolia*, *Gymnanthes lucida*, *Hippomane mancinella*, *Bourreria succulenta*, and *Tabebuia heterophylla*. Near the shore are zones of *Coccoloba uvifera* and coastal thickets of *Pithecellobium unguis-cati*. In the southwestern coastal plain are three species of mangroves, of which *Laguncularia racemosa* is commonest. Others are *Conocarpus erectus* and *Rhizophora mangle*, the latter in a small inland swamp. The fourth common mangrove species of the West Indies, *Avicennia nitida* Jacq., apparently is absent.



Fig._2.—Twelve-year-old plantation of *Swietenia mahagoni*
on the coastal plain.

At least four tree species of Mona Island are poisonous. *Metopium toxiferum* and *Comocladia dodonaea*, both related to poison-ivy of the United States, have oily sap that produces inflammation of the skin of many persons upon contact. The fruits of *Hippomane mancinella* have caused death when eaten. The white latex of that species and of *Euphorbia petiolaris* is irritating and toxic if taken internally.

GEOGRAPHICAL RELATIONSHIPS OF THE TREES

An analysis of the geographical distribution, or natural ranges, of the plant and animal species of an island will summarize the relationships and indicate the probable origins of the flora and fauna. The higher plants of the West Indies and their distribution, island by island, now are sufficiently well known for these compilations. For example, Beard (1)

has tabulated the ranges of the trees of the Lesser Antilles, and zoologists have made similar studies of certain animal groups.

Britton indicated the occurrence on nearby islands of the plant species of Mona Island. Of the 221 species, excluding thallophytes, undetermined, introduced, and four endemic species, 211 were in common with Puerto Rico, 185 with Hispaniola, 155 with Bahamas, and 87 with Curacao.

The ranges of the 74 native species of trees and large shrubs of Mona Island in the annotated list have been compiled largely from recent floras and lists. In Table 1 these species have been placed in 12 convenient groups according to their ranges. The same species can also be grouped according to their presence on other particular islands, as did Britton.

Thus, the native species of trees and large shrubs of Mona Island common to other islands and to the continent may be summarized as in Table 2.

Table 1.-The native species of trees and large shrubs of Mona Island in groups according to ranges

Range	Number of species
Restricted range, 11 species	
Endemic to Mona	0
Bahamas and Mona ¹	1
Cuba to Mona ²	2
Hispaniola to Puerto Rico ³	3
Mona and Puerto Rico ⁴	2
Mona to Lesser Antilles ⁵	3
Broad range in West Indies, 13 species	
Greater Antilles ⁶	2
Greater Antilles and Lesser Antilles	11
On continent in Florida or southward, 50 species	
Florida to Puerto Rico ⁷	2
Florida to Lesser Antilles	14
Florida through West Indies to continent	27
Greater Antilles through Lesser Antilles to continent	7
Total	74

Table 2.-Summary of distribution of Mona trees and shrubs.

Range	Number of species
Native to Mona Island	74
Mona and Puerto Rico	69
Mona and Hispaniola	68
Mona, Puerto Rico, and Hispaniola	64
Mona and Lesser Antilles	62
Mona and Bahamas	49
Mona and continent (Florida or southward)	50
Mona and Florida	43
Mona and continent south of Florida	34
Mona and Curacao	22
Mona and Bermuda	9

1 *Sarcamphalus taylorii*.

2 *Cereus hystric*, *Psychotria nutans*.

3 *Cacalaba obtusifolia*, *Pisonia alba*, *Jatropha multifida*.

4 *Ficus stahlii*, *Cereus portoricensis*.

5 *Cephalocereus rayenii*, *Opuntia rubescens* (?),

Antirrhoea acutata.

6 *Celtis trinervia*, *Plumeria obtusa*.

7 *Thrinax micracarpa*, *Chrysophyllum alivifarm*.

Endemic Species

In 1915 Britton (2) listed four endemic plant species of Mona Island, exclusive of thalophytes, publishing descriptions of three of these. *Tabebuia lucida* Britton, the only one that was a tree, is here reduced to synonymy. Of the two liverworts, or hepatics, *Riccia violacea* M. A. Howe was found later in Mexico, Bahamas, Cuba, and Puerto Rico, while *R. brittonii* M. A. Howe was reduced to a synonym of *R. elliotii* Stephani, of Yucatan, Cuba Puerto Rico, Virgin Islands, and Lesser Antilles to Trinidad. The fourth, *Euphorbia monensis* (Millsp.) Urban (*Chamaesyce monensis* (Millsp.)), is a very small prostrate perennial herb with stems less than 3 inches long and with large tap root. Thus, only one species of higher plants may now be listed as endemic to Mona, but it apparently has not been collected since 1914 or studied further. The percentage of endemic species of animals probably is larger.

Species not Native Also in Puerto Rico

Only five species of the native trees and large shrubs of Mona Island listed here have not been recorded in Puerto Rico. *Sarcomphalus taylorii* Britton is known only from Bahamas and Mona, while *Cereus hystric* Haw. is recorded from Cuba, Jamaica, Hispaniola, Mona, Desecheo, and Muertos (off the southern coast of Puerto Rico). The range of *Psychotria nutans* Sw. is here extended to Mona from Cuba and Hispaniola. *Calyptranthes pallens* Griseb. ranges from Florida to Mona, St. Croix, St. Thomas, and Guadeloupe, omitting Puerto Rico. *Forestiera rhamnifolia* Griseb., a rare species occurring from Cuba to Grenada, has been found at one locality on St. Croix and now in Mona but not on Puerto Rico.

One variety, *Dodonaea viscosa* var. *arborescens* (Hook. f.) Sherff (listed by Britton as a species, *E. ehrenbergii* Schlecht.), recorded from Florida to Mona, Anegada, and Désirade, also misses Puerto Rico. The range of *Plumeria obtusa* L., Bahamas to Mona, was broadened to Puerto Rico by the reduction of *P. krugii* Urban to synonymy.

Species not Native also in Hispaniola

Six of the species of Mona are absent from Hispaniola. *Sarcomphalus taylorii* Britton, of Bahamas and Mona, has been recorded neither from Hispaniola nor Puerto Rico. Five others, two from Puerto Rico and three from Puerto Rico and Lesser Antilles have their known western limit in Mona but may be sought in Hispaniola.

Species Also on Continent

Most of the 50 species of Mona Island that are native also on the continent (Florida or southward) have a wide distribution in the West Indies also or in tropical continental America. The 43 species common to Florida reached that former island from the West Indies, perhaps from Bahamas, which were larger and nearer before the Grand Banks were submerged, or from Cuba. Twenty-seven of these and seven others are found also southward on the continent in Central America (or Yucatan) or also southward to northern South America. Nearly all these species of Mona Island that are present in northern South America are also in Central America and apparently migrated along the continent. A detailed study of the species common to Mona Island and the continent would involve a large number of species and comparison of the floras of the Greater Antilles and Central America. These floras obviously are related, and a large element of the West Indian flora apparently migrated from Central America when the areas were connected by land bridges.

Conclusions

Thus, the arborescent flora of Mona Island is not distinctive or specialized, containing no endemic species, but is almost identical with that of both Puerto Rico and Hispaniola except for the smaller number of species. Most of these species of trees and large shrubs have a broad distribution in the West Indies, and two-thirds are native also on the continent. On Mona Island are found tree species characteristic of the dry forest of the West Indies as well as those widely distributed on tropical American shores.

Noting the absence of a specialized flora on this isolated island, Britton concluded that all the native species might readily have arrived through natural agencies and that it was unnecessary to assume a former land connection between Mona and either Puerto Rico or Hispaniola. Likewise, Guppy (4) in his detailed West Indian studies showed that seeds of many species were readily distributed by ocean currents, winds, and birds. The main direction of ocean currents and the prevailing wind at Mona are from Puerto Rico and the east-northeast.

Nevertheless, the geological evidence indicates that both Puerto Rico and Hispaniola were joined as a larger island similar to Cuba in the not far distant past and that Mona Island after its formation was much less isolated than now. Thus, the absence of endemic species in a seemingly isolated island is easily explained by the short period of separation rather than young age since uplift or ample migration from both sides. The recent rise in ocean levels up to 200 feet since melting of the last ice sheet of the glacial epochs may not have contributed significantly to isolation but may have affected the species of the coastal plain.

The restricted or irregular distribution of a few tree species, mentioned above, is to be expected. Those of small or local range may be relatively new species expanding their area, old declining species, or uncommon species with incompletely known distribution. Species of irregular distribution absent on certain islands may have spread slowly by accidents in migration.

The classic illustration of the rapid revegetation of the volcanic island Krakatoa makes an interesting comparison and shows how fast plant life can travel. That small tropical island of the East Indies has a somewhat similar location in the strait between Java and Sumatra being about 25 miles distant from both but also near other volcanic islands. The vegetation was destroyed by violent eruption in 1883, which also removed most of the island. Yet, within 50 years later, luxuriant forest vegetation was again present, and

Doctors van Leeuwen (3a) listed 271 species of seed plants and ferns in 1934. These had been transported apparently by wind, ocean currents, and animals (including a few by man). Thus, a new island in the location of Mona would be invaded by plant life by natural means though probably somewhat slower than Krakatoa because of the drier climate.

Introduced Species

Four tree species listed from Mona by Britton in 1915 apparently were introduced: *Ricinus communis*, *Gossypium* sp., *Carica papaya*, and *Terminalia catappa*. Twenty-two additional introduced tree species are listed here. These are mostly common fruit and ornamental trees of the tropics brought in by settlers, miners, and by the Forest Service. Perhaps a few of these may antedate Britton's visit of February 20-26, 1914. Two, *Casuarina equisetifolia* and *Swietenia mahagoni*, are forest trees now growing in extensive plantations. Several of these exotics are represented by only a few individuals or even a single tree. However, the list of introduced species may be worthy of record for future studies of the flora of this almost uninhabited island. At present only three, *Cocos nucifera*, *Sabal causarium*, and *Leucaena glauca*, appear to be reproducing naturally and spreading in the absence of cultivation. Whether these or others will in time become naturalized on the island remains to be seen.

ANNOTATED LIST OF TREES AND LARGE SHRUBS

This list of 100 species of trees and large shrubs of Mona Island includes both the authors collections and Britton's list of 1915 and contains notes on size, abundance, habitat, and range beyond Mona. (Curacao, as one of nearest South American islands was mentioned by Britton and is retained here in the range.) The 12 native species that are additions to Britton's list are indicated by an asterisk(*). Introduced species totaling 26 are designated by "(Introd.*)" for range, while the 22 not recorded by Britton are preceded by a dagger(†).

Naturally the number of tree species included will depend on the definition and minimum size limits accepted for a tree. Most species listed here probably attain at least 12 feet in height and 3 inches in diameter at breast height on Mona Island, unless otherwise noted, and may be accepted as sometimes becoming trees, even though commonly smaller and shrubby. Several species of large shrubs, mostly reaching tree size in Puerto Rico or elsewhere, have been inserted. If an apology for their inclusion is in order, it may be noted that the trees on these barren rock outcrops generally are smaller than under a more favorable environment.

Common names, seldom employed on this almost uninhabited island, have not been added here. However, the Spanish names applied to the same species in Puerto Rico are available for use if needed.

Palmae

† *Cocos nucifera* L. Four introduced palms not listed by Britton in 1915 are now found on Mona Island and may have been introduced earlier, the coconut probably before 1900. Coconuts have been planted along the sandy shore of Sardinera and a few also at Playa de Pájaros. Some of these palms are now 40 feet tall and reproducing. (Introd.)

† *Phoenix dactylifera* L. A few date palms have been introduced in cultivation at Sardinera but are not spreading. (Introd.)

† *Roystonea borinquena* O. F. Cook. A few trees probably of this species have been planted at Sardinera but are not increasing in number. (Introd. Native of Puerto Rico and Virgin Islands.)

† *Sabal causarium* (O. F. Cook) Beccari. A grove of fan palms, known as Palmar de Cogolla, apparently this species, is located on the coastal plain 3/10 mile northwest of Uvero, perhaps planted before 1900. The largest are 25 feet tall and are reproducing. (Introd. Native of Puerto Rico.)

Thrinax microcarpa Sarg. (*T. ponceana* O. F. Cook) A shrub to 10 ft. high with trunk becoming 3-7 feet high and 4 inches d.b.h.,

collected in fruit. Scattered and uncommon on the coastal plain between Sardinera and Uvero. (Florida to Puerto Rico and Vieques.)

Casuarinaceae

† *Casuarina equisetifolia* L. The plantations of this species totaling about 200 acres made by the Civilian Conservation Corps between 1937 and 1939 now contain the tallest trees on the island, up to 95 feet in height and 16 inches in diameter. Not spreading from cultivation. (Introd.)

Ulmaceae

Celtis trinervia Lam. To 25 feet high and 5 inches d.b.h. Base of cliffs at Sardinera. (Greater Antilles including Virgin Islands.)

Moraceae

† *Artocarpus altilis* (Parkinson) Fosberg. (*A. communis* Forst.) Three planted trees were noted at Sardinera. (Introd.)

Chlorophora tinctoria (L.) Gaud. Spreading tree 30 feet high and 6 inches or more d.b.h. Coastal plain near Sardinera. (Greater Antilles and Lesser Antilles to continent; Curacao.)

Ficus laevigata Vahl. To 30 feet tall. Coastal plain and plateau. (Florida to Lesser Antilles.)

Ficus stahlia Warb. To 40 feet tall and 1 foot d.b.h., frequent at base of cliffs, Sardinera. Collected in fruit. (Puerto Rico and Mona.)

Polygonaceae

Coccoloba diversifolia Jacq. (*C. laurifolia* auth., not Jacq.) Common on plateau and coastal plain. (Florida to Lesser Antilles.)

Coccoloba obtusifolia Jacq. To 15 feet high and 3 inches d.b.h. Common on plateau and coastal plain. (Hispaniola to Puerto Rico and Virgin Island.)

Coccoloba uvifera (L.) L. To 25 feet tall and 1 foot d.b.h., a shrub or tree of sandy beaches at Playa de Pájaros and southwestern coastal plain. (Florida through West Indies to continent; Curacao.)

Coccoloba venosa L. (*C. nivea* Jacq.) To 15 feet high and 1 inch or more d.b.h. Uncommon at base of cliffs near Sardinera. (Jamaica and Hispaniola to Trinidad.)

Nyctaginaceae

Pisonia albida (Heimerl) Britton. Spreading deciduous tree 20 to 30 feet high and 10 inches d.b.h., with stout smoothish light brown trunks and enlarged bases suggesting an elephant's foot. Common as one of the dominant trees in western part of the plateau, conspicuous from the air. Male flowers collected. Britton in 1915 listed *P. subcordata* Sw. doubtfully from sterile material, and Britton and Wilson cited *P. albida* (Heimerl) Britton. (Hispaniola, Mona, Puerto Rico, and Muer-tos.)

* *Torrubia fragrans* (Dum.-Cours.) Stand-ley. (*Pisonia fragrans* Dum.-Cours.) To 30 feet high and 5 inches d.b.h. Uncommon at base of cliff, Sardinera. (Greater Antilles and Lesser Antilles to continent; Curacao.)

Lauraceae

Nectandra coriacea (Sw.) Griseb. Tree recorded by Britton from base of cliff, Sardinera. (Florida to Lesser Antilles and on continent.)

Capparidaceae

Capparis cynophallophora L. Shrub of coastal plain. (Florida through West Indies to continent; Curacao.)

Capparis flexuosa L. Large shrub on coastal plain and plateau. (Florida through West Indies to continent; Curacao.)

Leguminosae

† *Delonix regia* (Bojer) Raf. Four trees to 20 feet high and 8-16 inches d.b.h. planted beside an old house at Uvero, and no seedlings. (Intro.)

† *Enterolobium cyclocarpum* (Jacq.) Griseb. A planted tree 70 feet tall and 14 inches d.b.h. at Sardinera. (Intro.)

† *Haematoxylon campechianum* L. A few trees to 20 feet high and 6 inches d.b.h., planted near Sardinera. (Intro.)

† *Leucaena glauca* (L.) Benth. A few small trees to 15 feet high and 3 inches d.b.h. near water holes at Las Caobas, on coastal plain 2 miles southeast of Sardinera. Perhaps introduced by livestock and beginning to spread. (Intro.)

Lonchocarpus (?) sp. Sterile and not identified. A tree 25 feet high and 5 inches d.b.h. at base of cliff, Sardinera, possibly introduced.

Pithecellobium unguis-cati (L.) Benth. With several stems from base and mostly shrubby, to 20 feet high and 2 inches or more d.b.h. Common forming thickets in coastal sands and plain at southwestern part of island. (Florida through West Indies to continent; Curacao.)

† *Tamarindus indica* L. Three planted trees at Uvero to 30 feet high and 1 foot d.b.h., not reproducing. (Intro.)

Erythroxylaceae

Erythroxylum areolatum L. Shrub or small tree to 15 feet high and 5 inches d.b.h., on coastal plain and plateau. At El Corral up to 20 feet tall and nearly 1 foot d.b.h. (Bahamas, Greater Antilles, and on continent.)

Zygophyllaceae

Guaiacum sanctum L. Shrub or small tree on coastal plain. Quantities of this valuable wood were removed in the past. (Florida to Greater Antilles and on continent; Curacao.)

Rutaceae

Amyris elemifera L. Shrub or small tree common on plateau and coastal plain. In a few areas goats have stripped bark from the trees, girdling them. (Florida to Lesser Antilles and on continent.)

† *Citrus aurantifolia* (L.) Swingle. A few lime trees to 15 feet tall and 3 inches d.b.h. have been planted at Sardinera and Uvero. (Intro.)

† *Citrus sinensis* Osbeck. Growth at Sardinera, oranges reportedly were introduced by the Spanish more than 400 years ago. (Intro.)

† *Triphasia trifolia* (Burm. f.) P. Wilson. A shrub 10 feet high cultivated at Sardinera. (Intro.)

Zanthoxylum punctatum Vahl. Coastal plain between Sardinera and Uvero, listed by Britton. (Hispaniola to Lesser Antilles and Trinidad.)

Burseraceae

Bursera simaruba (L.) Sarg. (*Elaphrium simaruba* (L.) Rose.) One of the dominant trees of the plateau and also on coastal plain, becoming 30 to 50 feet tall and 1 to 1½ feet d.b.h. (Florida through West Indies to continent; Curacao.)

Meliaceae

† *Swietenia mahagoni* Jacq. The Civilian Conservation Corps in the years 1937 to 1939 made plantations of about 200 acres on the coastal plain southeast of Sardinera and small experimental plots on the plateau. (Introd.)

Malpighiaceae

Byrsonima lucidum DC. (*B. cuneatum* (Turcz.) P. Wilson.) Occasional on coastal plain, according to Britton. (Florida to Lesser Antilles.)

Euphorbiaceae

Euphorbia petiolaris Sims. (*Aklema petiolare* (Sims) Millsp. in Britton Mo. Bot. Gard. Ann. 2:43. 1915.) Shrub or small tree to 20 feet tall and 5 inches d.b.h. Common on plateau and coastal plain. Apparently not poisonous to the touch. The latex caustic and toxic if taken internally. Though transferred to *Aklema* in Britton's list of 1915, this species was not credited to Mona by Britton and Wilson in their flora. The segregate genus *Aklema* generally is not now accepted. (Bahamas to Lesser Antilles.)

* *Cymnanthes lucida* Sw. Small tree to 15 feet high and 3 inches d.b.h., common and dominant locally in coastal plain and also on plateau. Recorded from Mona Island by Wadsworth and Gilormini (9). Florida to Lesser Antilles.)

Hippomane mancinella L. Spreading tree to 40 feet high and 16 inches d.b.h., common in southwestern coastal plain not far from shore and at Playa de Pájaros. The attractive slightly fragrant fruits are dangerously poisonous and have caused death when eaten. The white latex is also irritating and dangerous. (Florida through West Indies to continent; Curacao.)

† *Jatropha curcas* L. (*Curcas curcas* (L.) Britton & Millsp.) Small tree to 15 feet high and 5 inches in diameter, planted at Uvero and not spreading. (Introd.)

* *Jatropha multifida* L. (*Adenoropium multifidum* (L.) Pohl.) Handsome shrub or small tree to 15 feet high and 3 inches d.b.h., with scarlet flowers, rare at Bajura de los Cerezos and El Corral. A few plants apparently native were found in relatively moist sites in depressions at these two localities in the interior of the plateau, both far from human settlements. (Hispaniola, Mona, and Puerto Rico.)

Ricinus communis L. Large shrub or small tree of coastal plain at Sardinera and Uvero, introduced around buildings. (Introd.)

Anacardiaceae

Comocladia dodonaea (L.) Urban. Shrub to 12 feet high and 3 inches d.b.h., common on plateau and coastal plain. The oily sap is poisonous and causes inflammation of the skin upon contact. (Hispaniola to Lesser Antilles.)

† *Mangifera indica* L. Planted tree at Sardinera, rare. (Introd.)

Metopium toxiferum (L.) Krug & Urban. One of the dominant trees of the plateau, becoming 20 feet high and 12 inches in trunk diameter, and also on coastal plain. The poisonous sap is irritating to the skin upon contact. (Florida to Puerto Rico and Aguadilla in Lesser Antilles.)

Celastraceae

Crossopetalum rhacoma Crantz. (*Rhacoma crossopetalum* L.) Shrub to 10 feet high, with broadly elliptic to nearly orbicular leaves, uncommon on plateau and coastal plain. (Florida to Puerto Rico and Virgin Islands and on continent; Curacao.)

Gyminda latifolia (Sw.) Urban. Occasional on the coastal plain, according to Britton. (Florida through West Indies and in Mexico.)

Schaefferia frutescens Jacq. Shrub to 15 feet high and 2 inches or more d.b.h. Common on coastal plain and at El Corral. (Florida through West Indies to continent.)

Sapindaceae

Dodonaea viscosa (L.) Jacq. var. *arborescens* (Hook. f.) Sherff. (*D. ehrenbergii* Schlecht.; *D. viscosa* var. *spathulata* (Smith) Benth.) Shrub to 12 feet high on coastal plain and plateau. (The species distributed worldwide in tropics, including Puerto Rico. This variety from Florida to Hispaniola, Mona, and Anegada and Désirade in Lesser Antilles but not in Puerto Rico.)

Exothea paniculata (Juss.) Radlk. Base of limestone cliffs at Sardinera, according to Britton. (Florida to Lesser Antilles and in Guatemala.)

Hypelate trifoliata Sw. Shrub or small tree to 18 feet high and 8 inches d.b.h. on coastal plain and at El Corral. (Florida to St. Martin and Anguilla in Lesser Antilles.)

† *Melicoccus bijugatus* Jack (*Melicocca bijuga* L.) A few planted trees to 50 feet tall and 14 inches d.b.h. at Sardinera and Uvero, not spreading. (Intro.)

Rhamnaceae

Colubrina arborescens (Mill.) Sarg. (*C. colubrina* (Jacq.) Millsp.) Shrub or small tree to 15 feet high in coastal plain. Small plantations on sands with brackish subsoil were not successful, though some plants persist. (Florida through West Indies.)

Krugiodendron ferreum (Vahl) Urban. Tree to 30 feet tall and 12 inches d.b.h., on coastal plain and at El Corral. (Florida through West Indies; recorded from Curacao by Britton.)

Reynosia uncinata Urban. Shrub to 12 feet high and 3 inches d.b.h., common on plateau and on coastal plain. (Hispaniola to Anguilla in Lesser Antilles.)

Sarcomphalus taylorii Britton. Shrub to 15 feet high and 3 inches d.b.h. Rare at El Corral and elsewhere on plateau and recorded by Britton and by Britton and Wilson (Sci. Surv. P. R. 6: 358. 1926) as occasional on coastal plain. (Bahamas and Mona.)

Malvaceae

Gossypium sp. a few shrubs of wild cotton to 12 feet high and 3 inches d.b.h. are persistent near Uvero and at Playa de Pájaros, apparently after cultivation. Not collected but listed by Britton as *G. barbadense* L. (Intro.)

Hibiscus tiliaceus L. (*Paritium tiliaceum* (L.) St. Hill., Juss., & Camb.) Recorded by Britton from border of a swamp at Sardinera. (Florida through West Indies to continent and in Old World tropics.)

* *Thespesia populnea* (L.) Soland. Tree to 50 feet tall and 12 inches d.b.h. at Sardinera. (Florida through West Indies to continent and in Old World tropics.)

Sterculiaceae

Helicteres jamaicensis Jacq. Shrub becoming 12 feet in height and 2 inches d.b.h. On coastal plain and plateau listed from Mona by Britton in 1915 but not by Britton and Wilson. (Bahamas to St. Martin in Lesser Antilles.)

Guttiferae

Clusia rosea Jacq. Uncommon tree on coastal plain and plateau. (Florida through West Indies to continent; (Curacao.)

Canellaceae

Canella winterana (L.) Gaertn. Small tree 15 feet high and 3 inches d.b.h., on coastal plain and plateau Florida through West Indies.)

Caricaceae

Carica papaya L. Persisting and slightly spreading after cultivation, becoming more than 20 feet tall and 10 inches d.b.h., the trunk sometimes with 2 or 3 forks. (Introd.)

Cactaceae

Cephalocereus royerii (L.) Britton & Rose. Columnar tree cactus becoming 15 feet high and 5 inches d.b.h. Common at east end of plateau. (Mona and Desecheo to Antigua in Lesser Antilles.)

* *Cereus hystrix* Haw. (*Lemaireocereus hystrix* (Haw.) Britton & Rose.) This columnar tree cactus to 15 feet tall is common at east end of plateau though not listed by Britton. (Cuba, Jamaica, Hispaniola, Mona, Desecheo, and Muertos but not Puerto Rico.)

Cereus portoricensis (Britton) Urban. (*Harrisia portoricensis*) Britton.) This slender cactus becomes 15 feet high with few-branched or unbranched stem to 2 inches d.b.h. Eastern part of plateau and Playa de Pájaros. (Mona and southern Puerto Rico.)

Opuntia rubescens (Salm-Dyck) (?). (*O. catacantha* Link & Otto; *Consolea rubescens* (Salm-Dyck) Lemaire.) Flat-jointed tree cactus becoming 12 feet or more in height. Common on plateau and also on coastal plain. Though referred by Britton to this species, the plants at Mona resemble *O. moniliformis* (L.) Haw. (*Consolea moniliformis* (L.) Britton), a closely related species of Hispaniola and Desecheo, which has numerous areolae on the joints. Britton's specimens from Mona and Desecheo are similar. (Mona, Puerto Rico, Virgin Islands, and Lesser Antilles.)

Lecythidaceae

† *Barringtonia asiatica* (L.) Kruz. One tree now 25 feet tall with four forks about 8 inches d.b.h. has been planted near the wharf at Pla-

ya de Pájaros. This East Indian tree has been introduced into Puerto Rico only sparingly for ornament and shade. (Introd.)

Rhizophoraceae

* *Rhizophora mangle* L. There is a small inland mangrove swamp about 1½ mile south-east of Sardinera. The trees reach 40 feet in height and 6 inches in trunk diameter and have stilt roots to 5 feet high and many seedlings. No standing water was present in August 1954. (Florida through West Indies to continent and in tropical Africa; Curacao.)

Combretaceae

Bucida buceras L. Spreading tree to 30 feet high and 16 inches d.b.h., on coastal plain near Uvero. (Florida through West Indies to continent; Curacao.)

Conocarpus erectus L. Small tree to 15 feet high and 4 inches d.b.h. on coastal plain near shore. (Florida through West Indies to continent and in tropical Africa; Curacao.)

Laguncularia racemosa (L.) Gaertn. f. To 20 feet high and 5 inches d.b.h. In mangrove swamp and marshes of coastal plain. (Florida through West Indies to continent and in tropical Africa.)

Terminalia catappa L. Introduced on coastal plain. In Britton's list of 1915 but not cited from Mona by Britton and Wilson. (Introd.)

Myrtaceae

Calyptanthus pallens Griseb. Shrub 10 feet high and 2 inches d.b.h. perhaps also a small tree. Uncommon on plateau and cited by Britton from base of cliffs at Uvero. (Florida to Mona, Virgin Islands, and Guadeloupe but not Puerto Rico.)

Eugenia axillaris (Sw.) Willd. Shrub 8 feet high and perhaps also small tree, on coastal plain at base of cliffs and on plateau. (Florida to Lesser Antilles.)

Eugenia fragrans (Sw.) Willd. (*Anamomis fragrans* (Sw.) Griseb.; *E. fajardensis* (Krug & Urban) Urban.) Tree to 35 feet tall and 8 inches d.b.h., easily recognized by the smoothish orange brown bark, mottled with gray..

Uncommon on plateau and one of the characteristic tree species at El Corral. Also occasional on coastal plain, according to Britton. (Cuba to Lesser Antilles, known in Puerto Rico only from a sterile specimen collected at Fajardo.)

Eugenia myrtoides Poir. (*E. buxifolia* (Sw.) Willd.) Shrub to 10 feet high and perhaps also a small tree. Base of cliffs at Sardinera, southwestern coastal plain, and El Corral on plateau. (Florida to Lesser Antilles.)

Eugenia rhombea (Berg) Krug & Urban. Shrub 10 feet high and perhaps also a small tree. Base of cliffs at Sardinera, southwestern coastal plain, and at El Corral on plateau. (Florida to Lesser Antilles.)

† *Psidium guajava* L. Small tree 12 feet or more in height. Introduced on coastal plain but not common. (Introd.)

Theophrastaceae

Jacquinia barbasco (Loefl.) Mez. Shrub 8 feet high and perhaps also small tree, coastal thickets, coastal plain, and plateau. (Cuba to Lesser Antilles and continent; Curacao.)

Sapotaceae

† *Achras zapota* L. (*Sapota achras* Mill.) A tree 30 feet high and 12 inches d.b.h., planted near Sardinera on coastal plain. (Introd.)

Bumelia obovata (Lam.) A. DC. Tree to 25 feet tall and 6 inches d.b.h., frequent on coastal plain. Collected with immature fruits but found sterile by Britton. (Hispaniola through Lesser Antilles and on continent; Curacao.)

* *Chrysophyllum oliviforme* L. Tree 30 feet high and 4 inches d.b.h. on coastal plain near Sardinera, possibly introduced. (Florida to Puerto Rico.)

* *Dipholis salicifolia* (L.) A. DC. Tree 20 to 40 feet tall and 5 inches d.b.h., with old trunks to 24 inches d.b.h., collected with flower buds. Uncommon in western part of plateau. Britton in 1915 and Britton and Wilson doubtfully referred to this genus a sterile specimen from a tree 39 feet (12 meters) high

in the coastal plain at Sardinera. Listed from Mona Island by Wadsworth and Gilormini (9). (Florida to Lesser Antilles and continent.)

* *Syderoxylon foetidissimum* Jacq. Rare tree to 60 feet high and 24 inches in trunk diameter, collected with fallen fruits on ground. Coastal plain near Sardinera. (Florida to Lesser Antilles and on continent.)

Oleaceae

* *Forestiera rhamnifolia* Griseb. A rare shrub 10 feet high and 2 inches d.b.h., on plateau. Collected in 1896 at bluffs of Salt River, St. Croix, but not known from Puerto Rico. (Cuba, Jamaica, Hispaniola, Mona, St. Croix, Guadeloupe, Martinique, and Grenada.)

Apocynaceae

Plumeria obtusa L. (*P. krugii* Urban.) Shrub and in protected places a tree to 20 feet high and 6 inches d.b.h. Common on plateau, especially conspicuous in shrub thickets or cactus brush of eastern part, and on coastal plain. Britton and Wilson referred the plants from western Puerto Rico to a segregate species, *P. krugii* Urban, which has been reduced to synonymy by Woodson. (Bahamas to Mona and Puerto Rico.)

* *Rauwolfia lamarchii* A. DC. Shrub at Sardinera. (Cuba (?) and Hispaniola through Lesser Antilles to continent; Aruba but not listed from Curacao.)

Rauwolfia tetraphylla L. Shrub 12 feet tall and perhaps a small tree. Coastal plain and plateau. (Bahamas to St. Barts in Lesser Antilles.)

Boraginaceae

Bouyeria succulenta Jacq.. Tree to 20 feet tall and 4 inches d.b.h., common on coastal plain and plateau. (Cuba through Lesser Antilles to continent; Curacao.)

* *Cordia glabra* L. Several trees to 30 feet tall and 12 inches d.b.h. were found at Bajura de los Cerezos. Doubtless these trees gave their common name "cerezo" to the locality.

Foliage was collected, and fruits were seen high in the trees. (Cuba through Lesser Antilles to continent.)

Verbenaceae

Lantana involucrata L. Usually a shrub about 5 feet high but sometimes 10 feet or more in height and 2 inches d.b.h. and treelike. Common on the plateau, especially in the shrub thickets or cactus brush, where it is one of the dominant species. Apparently this species along with *Croton* spp. has increased with overgrazing by goats. Also common on coastal plain and forming thickets near beach. (Florida through West Indies to Tobago; Curacao.)

Bignoniaceae

† *Crescentia cujete* L. One tree 18 feet high and 4 inches d.b.h., perhaps planted, on coastal plain at Sardinera. Listed from Desecheo by Britton and Wilson. (Introd.)

Tabebuia heterophylla (DC.) Britton, Mo. Bot. Gard. Ann. 2:48. 1915. (*T. lucida* Britton, Mo. Bot. Gard. Ann. 2: 48. 1915; *T. pallida* (Lindl.) Miers.) Small tree becoming 15 feet or more in height. One of the dominant trees on the plateau and common also on coastal plain and at Playa de Pájaros. Publishing this combination in his Mona list of 1915, Britton mentioned the leaves as 1-5-foliolate and recorded the distribution as frequent on the coastal plain and on the plateau. On the same page appeared the new species *T. lucida* Britton as a tree to 16 feet (5 meters) high with 3-5-foliolate leaves and shiny leaflets, from limestone cliffs, Sardinera (Britton, Cowell, and Hess 1886). Britton and Wilson credited both species to Mona, citing the latter as endemic on limestone cliffs of Mona.

The type specimen of *T. lucida* Britton has been examined at New York Botanical Garden, and topotypes were collected on the limestone cliffs at Sardinera in 1954 and 1955. In the original description this species was compared with no other, but Britton and Wilson in their key separated this species by leaflets narrowly oblong or oblanceolate, strongly shin-

ing, and loosely reticulate-veined. However, the leaflets are not separable from those of *T. heterophylla*, and the shiny surface seems inconstant and not significant.

Therefore, after field and herbarium study, *T. lucida* Britton is here reduced to synonymy, as only a single species of this genus is distinguishable on Mona Island. Also *T. pallida* (Lindl.) Miers, originally described from the variation in the Lesser Antilles with large simple leaves and recorded also from Puerto Rico and Virgin Islands, apparently cannot be maintained as a separate species. Britton and Wilson stated that *T. heterophylla* perhaps was not specifically distinct from *T. pallida*. When the two are united, the former name, which has priority, should be adopted. The latter has also been treated as a subspecies, *T. heterophylla* subsp. *pallida* (Lindl.) Stehlé. (Hispaniola to Lesser Antilles.)

Rubiaceae

Antirhea acutata (DC.) Urban. (*Stenostomum acutatum* DC.) Shrub or small tree to 12 feet high and 3 inches d.b.h. Common on sand dunes, coastal plain and plateau. (Mona, Puerto Rico, Muertos, Vieques, Antigua, Barbados, and Guadeloupe, and Bonaire, Curacao, and Aruba.)

Erithalis fruticosa L. Shrub or small tree to 15 feet high and 3 inches d.b.h. Common on coastal sand and on coastal plain and plateau. (Florida through West Indies and on continent; Curacao.)

Exostema caribaeum (Jacq.) Roem. & Schult. Small tree to 20 feet high and 3 inches d.b.h. Frequent on coastal plain and plateau. (Florida through West Indies and on continent.)

Guettarda elliptica Sw. Small tree 12 feet high and 3 inches d.b.h. Uncommon on plateau and at Bajura de los Cerezos and listed by Britton as occasional on coastal plain. (Florida through West Indies to continent.)

* *Psychotria nutans* Sw. Small tree to 15 feet in height and 6 inches d.b.h. rare at Bajura de los Cerezos. It is easily recognized by

the very thick bark with light brown ridges and deep furrows. (Cuba, Hispaniola, and Mona.)

Randia aculeata L. (*R. mitis* L.) Shrub 8 feet or more in height, common on coastal plain and plateau. (Florida through West Indies to continent; Curacao.)

SUMMARY

Mona Island, an area of about 21 square miles, is located in Mona Passage about midway between Puerto Rico and Hispaniola and belongs to the former. In 1915 N. L. Britton published a list of the flora of the island.

The trees and large shrubs of this island, with additions found by the author in 1954 and 1955, are listed with notes. The 100 species comprise 74 native, including 12 additions to Britton's list, and 26 introduced, including 22 additions, mostly cultivated.

The arborescent flora is almost identical with that of both Puerto Rico and Hispaniola except for the smaller number of species, 64 of the 74 native species listed being present on both larger islands. Most of the species of trees and large shrubs of Mona Island are widely distributed in the West Indies, and 50, or two-thirds, occur also on the continent. No tree species is endemic, but 1 herbaceous species is not known elsewhere. *Tabebuia lucida* Britton, described from Mona Island, is here reduced to a synonym of *T. heterophylla* (DC.) Britton.

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Caribbean Forester

El "Caribbean Forester", revista que el Servicio Forestal del Departamento de Agricultura de los Estados Unidos comenzó a publicarse en julio de 1938 se distribuye semestralmente sin costo alguno y está dedicada a encauzar la mejor ordenación de los recursos forestales de la región del Caribe. Su propósito es estrechar las relaciones que existen entre los científicos interesados en la Ciencia Forestal y ciencias afines encarándoles con los problemas confrontados, las políticas forestales vigentes y el trabajo que se viene haciendo para lograr ese objetivo técnico.

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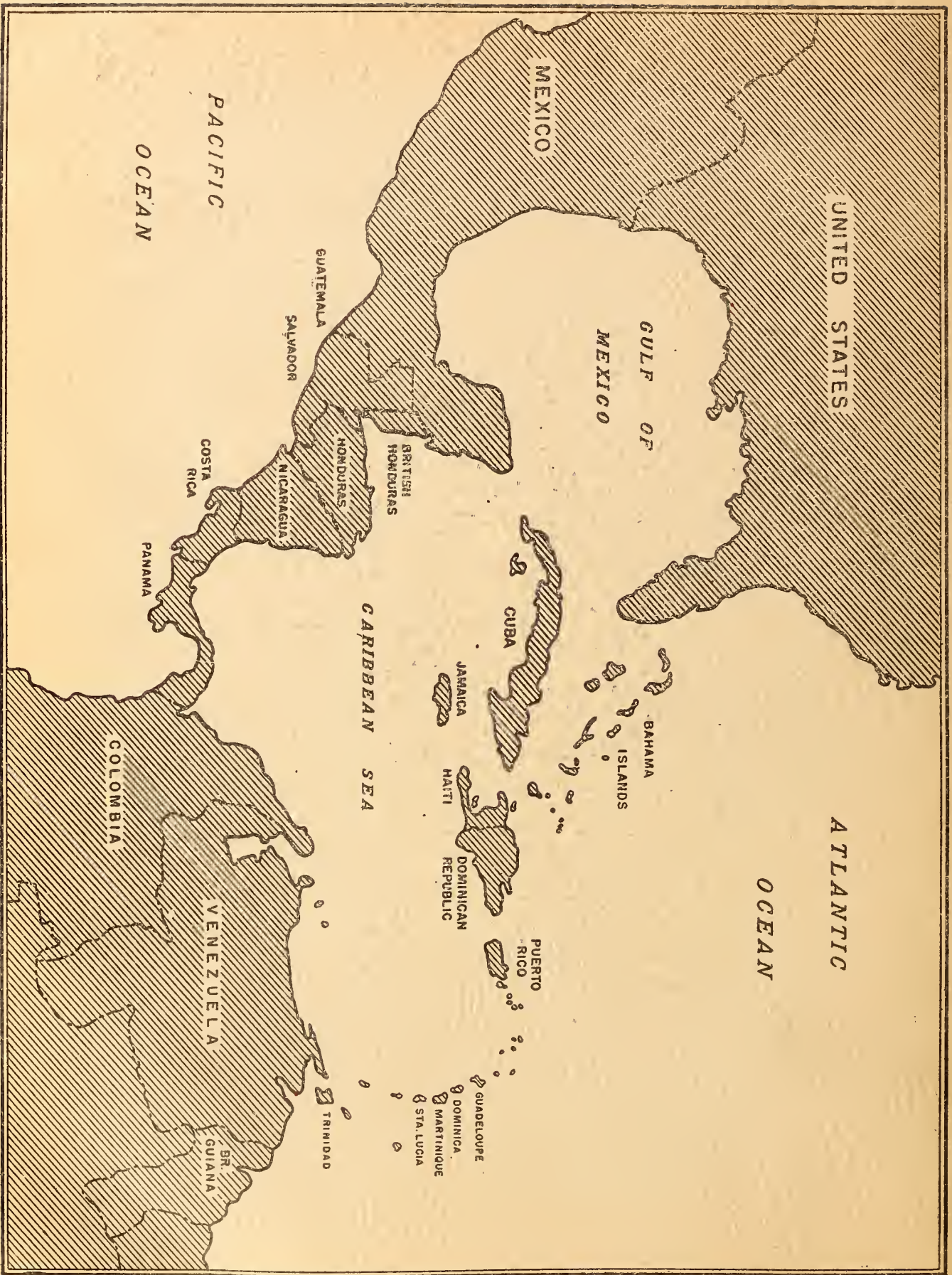
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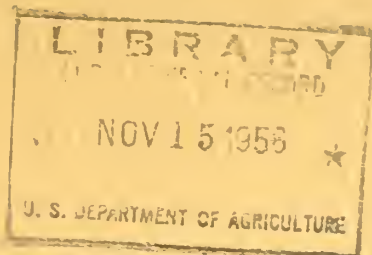
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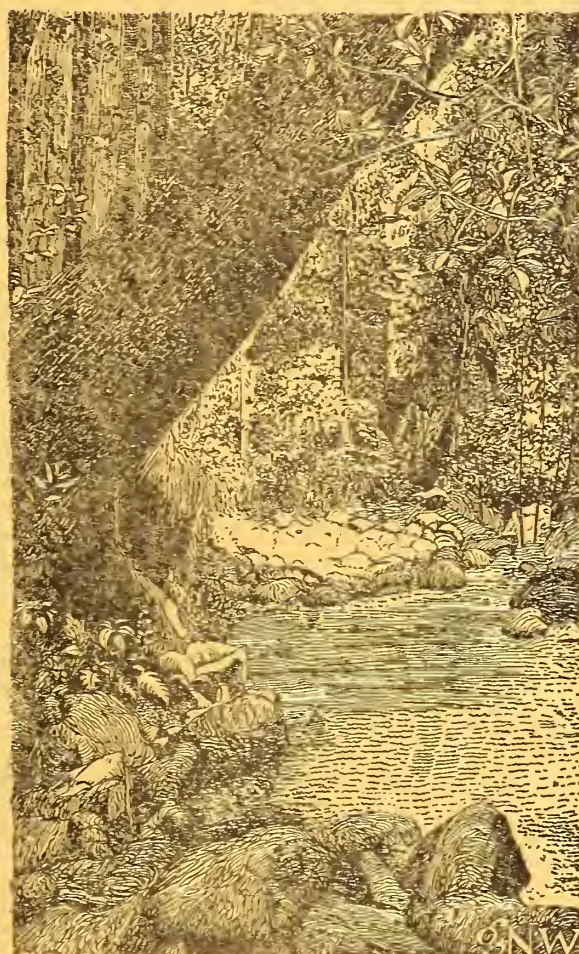


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The

Caribbean Forester



U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

TROPICAL FOREST EXPERIMENT STATION
RIO PIEDRAS, PUERTO RICO

Caribbean Forester

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The Caribbean Forester

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LAS PLANTACIONES DE EUCALIPTO DE LA MANAJA, MINAS DE MATAHAMBRE

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Finalidad de las Plantaciones

Con motivo de que los "pinares" se están agotando y con objeto de producir sus necesidades en "bocaminas", previsoriamente, la Compañía Minas de Matahambre, S.A. inició en 1949 un amplio programa técnico de plantaciones forestales bajo la dirección de un Selvicultor.

Terreno Escogido

Se seleccionó un terreno de manigua y de cultivo, en su mayor parte aluvial, por ser en las cercanías de un río de pendiente variable, en la finca de la Manaja y más tarde otro llano y de sabanas rojas en la finca Cabezas de Horacio, ambas al Norte de la Provincia de Pinar del Río.

Técnica de las Plantaciones

Se utilizó con éxito el sistema de semilleros con aplicación de abono químico (3-8-2). Las posturas o brinzales se transplantan cuando tienen de 4 a 5 pulgadas de altura a macetas de papel alquitranado. Debe tenerse cuidado con los semilleros en cuanto a los riegos y la selección del suelo. Este debe ser lo más desprovisto posible en materia orgánica y los riegos moderados a fin de mantener en el suelo la humedad necesaria al desarrollo de pequeñas plantitas, pues si ésta es excesiva se tendrán frecuentes ataques de "damping off" u otros hongos muy dañinos en los semilleros de eucalipto.

Debe ofrecerse protección contra los aguaceros fuertes durante los primeros días de la germinación. Los mejores semilleros se han logrado en los meses de enero a marzo.

Cuando las posturas en las macetas han alcanzado una altura de 40 a 50 centímetros, son llevadas al campo para su plantación definitiva (las hemos plantado hasta de 1 metro de altura con buen resultado), lo que se realiza durante los meses de lluvia. Los mejores meses para plantar aquí son junio y julio. Se ha practicado con éxito el sistema de hoyos a distancia de 2, 5 y de 3 metros en cuadro.

Antes de plantar es necesario destruir todos los bibijagueros o nidos de bibijaguas (*Atta insularis*) que haya en el campo ya que causan daños considerables al eucalipto (pudiendo considerarse el único enemigo de importancia) llegando a destruir una plantación joven en poco tiempo.

Cuando se planta terreno de monte o manigua, es necesario chapear las mañezas durante los primeros años, especialmente los bejucos, a fin de permitir el crecimiento libre de los árboles. Después de los 3 ó 4 años, la sombra natural resulta suficiente. En los suelos de sabana donde la vegetación espontánea está constituida en su mayoría por gramíneas, o en otro tipo de suelo desprovisto de maniguas, no es necesario chapear si se les da una buena preparación de arado, lo que hace que la plantación resulte mucho más económica.

^{1/} Resumen del seminario ofrecido por el autor del día 9 de septiembre de 1953, en la Escuela Nacional Forestal en una reunión técnica organizada por la Sociedad Económica de la América Tropical

Especies

Se ensayaron las siguientes especies, clasificadas según la bondad que demostraron en las plantaciones:

Eucalyptus saligna
Eucalyptus tereticornis
E. paniculata
E. maculata
E. citriodora
E. robusta
E. rostrata (no dió resultado)
E. myrcocoris (no dió resultado)
E. pilularis (este no germinó)

De todas las especies *Eucalyptus saligna* es la más prometedora y forma la mayor parte de las plantaciones. Se destaca por su rápido crecimiento (en 4 años tiene 6 pulgadas y 15 metros de alto en promedio), forma muy recta del fuste, magnífica poda natural, resistencia a las condiciones del suelo, reducido número de fallas en el trasplante y facilidad para manipularlo en el vivero.

Aspecto Económico

En un análisis de los costos de una postura al año de haber germinado, se estableció que los mayores gastos resultan de las chapeas, desmonte o limpieza del terreno, la apertura de hoyos, limpieza y trabajos del vivero y los gastos de plantación. Estos y otros gastos menores, (sin incluir costo de materiales) suman el costo de un arbolito de un año en \$0,108. Este análisis corresponde a una plantación de 103.130 eucaliptos reali-

zada en 1950 en la finca La Manaja, en terreno de monte y manigua donde hay que hacer chapeas posteriores a la plantación.

En otro análisis de una plantación de 18.000 eucaliptos realizada en la finca Cabezas de Horacio, en un terreno de sabana rojas, al que se le dieron dos labores de arado y dos de grada, resultó que el costo de un arbolito ya plantado en el campo incluyendo el importe de materiales e inclusive la aplicación de abono químico a la plantación fué de \$0,103.

Resulta más económica, por no tener que hacer gastos en chapeas, ya que en este tipo de suelo no se desarrolla vegetación que perjudique el eucalipto, a la vez que se obtiene un mayor rendimiento del trabajo de cada obrero. Un ejemplo demostrativo de lo que se acaba de afirmar es el siguiente: En La Manaja un obrero puede plantar como promedio 200 eucaliptos al día, mientras que en Cabezas de Horacio fué de 400 el promedio. Este hecho se debe a que el terreno laborado se trabaja con más facilidad. Además un suelo laborado cualquiera que sea el tipo, tiene la ventaja de que las plantas encuentran condiciones favorables para desarrollar sus raíces, resultando un crecimiento más rápido y desarrollo uniforme de toda la plantación.

Cantidad y Especies Forestales Plantadas

Se han plantado hasta la fecha 312.627 *Eucalyptus* y 45.043 árboles de otras especies forestales mayormente cedro.

MARKETING OF CARIBBEAN TIMBERS

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Introduction

This paper discusses the marketing possibilities of timbers produced in the Caribbean area. Both the Caribbean market as well as the extra-Caribbean market will be considered. Main source of information used in preparing this paper is the documentation prepared for the "Conference on Caribbean Timbers, Their Trade and Utilization Within the Area", organized by the Caribbean Commission, held in Port of Spain, Trinidad, April 15-22, 1953, and mentioned hereunder for the sake of brevity as the Timber Trade Conference.

This documentation describes conditions found in the countries served by the Caribbean Commission. It may be assumed, however, that conclusions which have been formulated in view of the conditions in these countries, will also be valid for other Caribbean countries.

Production

Apart from pine produced in British Honduras and the Bahamas, the countries served by the Caribbean Commission produce practically only hardwoods and no softwood.^{1/}

The terms hardwoods and softwoods are used here in the traditional meaning which they have in wood technology, indicating that softwoods originate from coniferous trees and hardwoods from broad-leaved trees. These terms, however, are not directly related to the mechanical hardness of the timber.

The hardwood forests of the area, which produce by far the greater part of the timber of the area, are in general characterized by a great variety of timbers, many of which have had little economic value up to the present.

In many forest areas economic utilization of the timber is difficult because the number of really valuable species per acre is low. The great variety of timbers is a difficulty in marketing because many of them are hardly known outside the producing country. There is a reasonable production of Caribbean timber but without any doubt this production could be increased considerably if certain obstacles to increased utilization were removed.

Data on production and consumption of timbers (hardwoods and softwoods together) of the countries served by the Caribbean Commission are given in Table 1. They have been taken from the FAO Yearbook of Forest Products Statistics 1953 except the figures marked *, which have been taken from the 1951 Yearbook.

The table gives figures for production and consumption (hardwoods and softwoods taken together). The production figures, however, refer practically to hardwoods only, except in the case of British Honduras, where the figure of 78,000 cubic meters represents 44,000 cubic meter hardwoods and 34,000 cubic meter softwoods.

The Caribbean Market

In discussing the Caribbean market one of the main subjects is the problem as to how far imported softwoods can be replaced by locally produced timber.

Lumber imports of the countries served by the Caribbean Commission originate mainly from North America and consist nearly entirely of softwoods. Pitch pine, Douglas fir, Canadian red cedar, white pine, spruce and hemlock are important imported species. They are used mainly for construction purposes.

^{1/} The Dominican Republic is also an important producer of pine in the Caribbean Area.

TABLE 1

Country	Estimated population	Timber production in cu. m. per year (1952)	Average consumption in cubic meters per 1000 inhabitants per year			
			Roundwood			
			Roundwood total	Fuelwood including wood used for charcoal and distillation	Industrial roundwood including saw logs	Sawn lumber
Barbados	210,000	negligible	—	—	—	130
Br. Honduras	66,000	78,000	620	200	420	110
Guadeloupe	290,000	—	140	50	90	45
Jamaica	1,400,000	4,000	30	1	29	20
Martinique	273,000	—	90	20	70	25
Puerto Rico	2,210,000*	3,828,000	—	1,070*	—	—
Trinidad and Tobago	630,000	148,000	330	60	270	70
Br. Guiana	420,000	346,000	480	340	140	210
Surinam	219,000	323,000	1,320	910	410	340
Fr. Guiana	26,000	—	—	—	—	270
Netherlands Antilles	158,000*	—	—	—	—	290*

The countries served by the Caribbean Commission imported during the year 1950 from outside the area roundwood timber to an amount of \$1,160,000 U. S. and sawn lumber to an amount of \$11,250,000 U. S. Inter-Caribbean trade in similar (softwoods) timbers was restricted to pine from British Honduras and from the Bahamas. This inter-Caribbean trade amounted to approximately \$1,200,000 U. S. during the same year.

The main problem for the Caribbean market seems to be how far locally produced hardwoods can replace imported softwoods. The imported softwoods have the advantage of being available in standard grades and sizes and adequately seasoned. Moreover

they are a limited group of which the properties are well known to the consumer.

They have, at least in the Caribbean area, the disadvantage of being easily attacked by termites. However, this disadvantage can be reduced considerably by termite proofing with appropriate chemicals. It may be true that the ideal anti-termite treatment has not yet been found, but without any doubt processes for impregnation exist which can reduce termite damage to a level which is not of great importance. Jamaica reported favourably on the use of tanalith^{2/}; Surinam on xylamon C 20^{3/}.

On the other hand the Caribbean hardwoods represent quite a heterogeneous collection of timbers of the most varying properties.

2/ Summary of the proceedings of the Aided Self-Help Housing Seminar Workshop held in Puerto Rico, October 1953, p. 53.
3/ Report of the Surinam Forest Service for the year 1950, p. 30.

Density ranges from the very light balsa wood with a specific gravity (air dry) below 0.2 to very heavy timbers such as the timber known in British Guiana as Banya (Ebony) which may have specific gravity (air dry) up to 1.35.

The heavier of the Caribbean timbers usually are very strong and durable and are excellently resistant to decay and to attacks by termites. However, the high density is also correlated with the property of being difficult to work. It is often necessary to pre-bore before nails can be driven. These objections of course are what the French call "les défauts de leurs qualités" (undesirable properties directly correlated with highly desirable qualities), but nevertheless they result in a certain preference from the viewpoint of the carpenters for imported softwoods.

In order to determine whether this preference for imported softwoods, at least from the carpenters' viewpoint, has a sound economic basis, increase of labour costs as a result of difficulties in working with hard and durable Caribbean timbers should be considered, also taking into account timber prices and timber durability.

On the other hand it should be kept in mind that the Caribbean area can also produce timbers that have hardness and workability, comparable to imported softwoods. Hitherto relatively little use has been made of these timbers because they are traditionally regarded as inferior. However, there is no doubt that if properly seasoned or kiln-dried and duly treated to make them termite-proof, they might compete with imported softwood timbers as an easily workable construction material.

A second objection against the use of Caribbean timbers is their lack of dimensional stability. This is, however, only a result of the fact that the timber used is not adequately seasoned and hardly ever kiln-dried.

Sawmillers often say that they are quite willing to supply adequately seasoned sawn lumber, but complain about the consumers who are not willing to pay the extra costs which the sawmiller charges to balance costs incurred in seasoning and the interest of the capital tied up during the period of seasoning. It seems that education of the buying public is necessary to make it realize that the improvement in quality is well worth the increase in cost.

A third disadvantage of the Caribbean timbers is that many different species exist and most of them are found only in a few producing countries. Many timbers of excellent qualities are therefore hardly known outside their country of production and their export to other Caribbean countries is difficult because they are not known there.

At the Timber Trade Conference approximately 350 timber species were reported as being marketable. Of course, no consumer who is not an expert will be able to say which of these 360 will suit his requirements best. Being embarrassed by a choice of too many timbers of which he knows very little, he will often choose the traditional imported timbers which can be supplied in well defined standard grades and of which he can find figures about allowable working stresses in every handbook.

The Timber Trade Conference recognized the danger of having too many timber species entering the trade and accepted among others the following two resolutions:

"3. *Group Marketing.*—Forest Departments, in consultation with Timber Trade should, in each of the major producing territories, compile lists of lesser known timbers to permit marketing. The Trade should then put these groups on the market. The Governments of producing countries should ensure the identity of the timbers shipped and should take the lead in the utilization of these grouped timbers by purchasing them for public purposes."

"8. *Timbers*.—The Caribbean Commission should approach the Forest Services of the United States in a effort to secure assistance from its Tropical Region in Puerto Rico in the compilation for publication of a list of the timbers of present and potential regional importance. This document should cover the entire Caribbean region, including the Independent Republics and should include trade names and all available data on timber properties and known uses. It should also outline research still required to enable the completion of the information. The Commission should offer the data collected by this Conference as a start on this project. Included is the preliminary list of 50 timber species prepared by the Conference and a suggested questionnaire also prepared by the Conference for the collection of the descriptive information regarding these important timbers."

The philosophy of resolution 8 apparently is that a limited number of timbers may have a chance of becoming well known and accepted in intra and extra—Caribbean trade, but that this will be impossible for some hundreds of types of timber.

The list of approximately 50 timbers is still open to amendments, and the publication describing these timbers in a form which permits easy consultation by the consumer is not yet available. But it is awaited with much interest and will certainly be of great assistance in developing the Caribbean timber trade.

The system of group marketing suggested in Resolution 3 will enable the producers to alleviate difficulties in utilizing the lesser known timber species, which are scattered in occurrence and do not individually permit regular large shipments. Timbers which have similar properties, particularly those suited for construction, might be grouped under a trade name which would establish a standard acceptable for the consumer, yet flexible for the producer.

The expected publication describing approximately 50 Caribbean timbers will include, of course, the timbers which are already fairly well known such as Demerara greenheart, wallaba, mora, crabwood, purple heart, mahogany, Central American cedar, Santa Maria, and Caribbean pine. But even for these timbers publication of literature which make their properties known to the consumers is very desirable, notwithstanding the fact that some good descriptions are already available, prepared by the forestry services of the producing countries.

The heavier among the Caribbean timbers have an advantage in that they are very strong and this quality might be used to promote their sales, at least for use as constructional timber. This advantage, however, is by no means fully used.

In moderate climates oak is regarded as a first class constructional timber. However, Demerara greenheart can take bending stresses and compressive stresses (parallel to grain) respectively 1.9 and 2.7 times that of oak. For Surinam greenheart, these relations are respectively 2.4 and 2.9; and for the timber known in Surinam as Yzerhart (Iron Heart) and in British Guiana as Banya, these relative figures are respectively 3.1 and 3.4.^{4/}

The reasons why architects and structural engineers hesitate to use the heavier of the Caribbean timbers according to their excellent strength properties, is, to a considerable extent, due to lack of knowledge of allowable working stresses.

Every handbook on structural engineering contains data on strength of the well known timbers of the moderate climates, but data on Caribbean timbers are hard to find. But even if the architect knows about these high strength properties he will be hesitant to use this knowledge fully in the interest of economic construction, because imported

4/ These strength ratio relations have been calculated from the table of recommended working stresses in Pfeiffer: *De Houtsoorten van Suriname* (Surinam Timbers).

structural timbers are graded according to strength properties and Caribbean timbers are not. However, even under existing circumstances and without recognized and accepted grading systems design of constructions could often be more economical if the excellent mechanical properties of Caribbean timbers were taken into account.

The table at the end of this article gives some further details about mechanical and other properties of some selected timbers. This table, however, is only illustrative and is not intended to cover the matter fully.

Marketing possibilities of Caribbean territories, however, do not depend only on increased use by substituting Caribbean timbers for imported softwoods. It is also essential to retain the traditional market.

In some Caribbean countries where timber was up to recently the traditional construction material for residential houses, there is a tendency to replace timber by concrete blocks or other stone blocks. Increased timber prices and maintenance costs of timber houses are the main reason.

If marketing possibilities for Caribbean timbers are not to be influenced unfavourably it is desirable that timber construction should remain competitive in comparison with other construction methods.

A remarkable initiative in this respect has been taken by a Surinam sawmill which is now selling precut timber for complete houses, cut exactly to the actual size needed. The system has the advantage for the sawmill of opening up possibilities for the sale of small sizes of lumber and also timber species for which there is little demand, but which may be quite adequate and useful, if necessary, after proper chemical treatment. According to reports received, the complete amount of precut timber needed for a house of 680 square feet floor surface is sold for Sur. fl. 1,850; the total cost of materials will be Sur. fl. 3,650 (\$970 U. S. and \$1,918 U. S. respectively). This house will contain living room,

kitchen, showers, lavatory and three bedrooms. The precut timber is ready for immediate assembly.

The Extra Caribbean Market

In the extra-Caribbean market the Caribbean timbers will not be sold, at least not in the near future, for general use. They will only have the possibility of being marketed for very specialised purposes. One of the traditional uses of Caribbean timbers in the overseas markets is for marine construction, in view of the fact that some of these timbers are known to be excellently resistant to marine borers, especially manbarklak and Demerara greenheart.

A relatively new overseas market which apparently has not yet been fully explored is the use for parquet flooring. The extreme hardness of many Caribbean timbers, their beautiful appearance and the possibility of using small sizes seem to make this an attractive proposition.

The possibility of exporting Caribbean timbers for decorative purposes, more or less as a luxury timber, apparently has not been fully explored. Indeed, it has been tried several times, so far without much success, except for mahogany from British Honduras. One of the reasons why previous attempts failed was that it was difficult to guarantee a regular supply. Introduction of high grade Caribbean timbers on overseas markets as a luxury timber therefore requires building up of stocks of well seasoned high grade timber from which orders can be shipped immediately. Obviously, this requires a considerable amount of capital. Any endeavour to explore and increase this market, therefore, should be restricted to selected timber which could be stocked.

One of the ways in which the export of Caribbean timbers to overseas markets has developed recently is in the form of railway sleepers. Surinam especially developed this export to the Netherlands after the war.

Conclusions

The following measures offer possibilities for expanding the market of Caribbean timbers:

A. *For the Caribbean Market*

1. Improved seasoning and increased introduction of kiln-drying.
2. Encouragement of use of properly seasoned or dried timber instead of green timber.
3. Standardisation of milling sizes and introduction of proper grading systems.
4. Increased use of some relatively unknown but nevertheless useful timbers, especially those which have good possibilities as substitutes for imported softwood timbers. Where appropriate, group marketing should be introduced, using trade names which comprise different timbers of similar properties.
5. Dissemination of information on Caribbean timbers, especially those of actual and potential regional importance.
6. Efforts to increase exports to Caribbean and overseas markets should be restricted to timbers of actual and potential importance. Of these timbers adequate stocks of well seasoned material should be kept on hand so that delivery could be made immediately on receipt of orders.
7. Dissemination of information on termite proofing treatments and encouragement of such treatment wherever appropriate.
8. Scientific design of timber construction wherever the excellent properties of many Caribbean timbers to carry heavy loads may be important.
9. Increased use of electrically powered small tools to alleviate difficulties in working the heavier of the

Caribbean timbers and to prevent bad workmanship (for instance omission of preboring when this may be necessary to prevent splitting).

10. Systematic study by sawmillers of possibilities of marketing timbers which are not in frequent demand and of small sized timber. Selling of houses in precut sizes, ready for assembling, is one possible solution.

B. *For the Extra-Caribbean Market—*

Conclusions 1, 3, 5, 6, 8 and 9, given above for the Caribbean market refer also to the extra-Caribbean Market. For the extra-Caribbean market the following additional conclusions may be formulated:

11. Propaganda of the use of appropriate Caribbean timbers, not yet adequately known in overseas markets, as ornamental luxury timbers or as parquet flooring.
12. Further economic study of the possibilities of using Caribbean timbers as a constructional or utility timber in overseas markets. In studies of this nature the exceptional ability of some Caribbean timbers (as well as of other heavy tropical timbers) to carry heavy loads should be taken into account. Most studies of this nature made in past years will not have paid full attention to this point. Possibilities of export of railway sleepers might be examined further.

It might be considered whether or not a further conclusion should be added regarding the reduction of cost price by improving the systems of forest utilization and sawmilling methods. Reduction in cost, price, of course, would increase marketing possibilities considerably. This angle of the problem, however, is an entirely different story and will not be discussed in this article.

APPENDIX

Timber name	Botanical identification	Timber description	Specific gravity (Air dry)	Modulus of rupture static bending (Air dry)	Maximum compressive strength parallel to grain (Air dry)
Yzerhart (Surinam)	<i>Swartzia</i> species	Brittle, difficult or impossible to nail.	1.05-1.35	33,500	19,700
Benya (British Guiana)		Difficult to work. Very strong and hard. Resistant to decay. Turns well. Polishes beautifully.			
Fabebuia	<i>Tabebuia serratifolia</i>	Very strong, very resistant and tough. Difficult to work.	1.00-1.15	28,000	18,500
Demerara greenheart	<i>Ocotea rodioi</i>	Greenish yellow to olive brown to blackish, medium fine textured, lustrous, very hard and heavy, very strong, almost immune to decay and termites, highly resistant to marine borers and fire, moderately hard to work. Finishes well, takes a high polish, must be prebored for nails.	0.96-1.12	22,400	12,800
Possumwood	<i>Hura crepitans</i>	Soft, easily attacked by termites when untreated. Goodworking properties. Darker types for interior construction, yellow types for furniture. White grades suitable for crates, plywood and veneer.	0.34-0.45	8,950	4,570
Oak	<i>Quercus</i> spec. div.		0.63-0.71	8,800	6,250
Douglas Fir	<i>Pseudotsuga taxifolia</i>		0.48	10,380	5,000

INDUSTRIAL WOOD USE IN PUERTO RICO

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Nearly one-fifth of the land area of Puerto Rico is or should be in forests, according to a recent study by the Puerto Rico Planning Board. This area of more than 400,000 acres is sufficient to provide a large portion of all forest products required for certain purposes and perhaps under intensive forest management to leave an exportable surplus of high quality hardwoods. However, the management and utilization of the forests is complicated by the presence of hundreds of tree species, many of excellent quality and others of no apparent value. Research must provide the knowledge for the management and utilization of the many species growing in this large potential forest area in an otherwise land-deficient, over-crowded island. With the knowledge gained through research a well informed, interested government can do much to provide the incentive and, in some places, the facilities for the proper use of these lands.

Research in forest management has been underway in Puerto Rico for nearly two decades but only slight attention has been given to the study of forest utilization. Much has been learned concerning the management of the very heterogenous forests of Puerto Rico but relatively little is known about the qualities and uses of the one-hundred or more species growing to sawlog size and the many other species reaching post and pole dimensions. Consequently, when in 1954 circumstances allowed the intensification of research in forest utilization the first task was to determine the status of present wood use on the island. This report, based upon the survey, is not intended as a problem analysis for the entire field of forest utilization but is principally a summarization of industrial wood use on the island.

The overall purpose of the survey was to determine the pattern of industrial wood use in Puerto Rico. The survey was intended primarily to determine the volume of wood used by species in the different industries, what the wood was used for, how it was used, what the problems were, and, to some extent, what could be done to relieve them. Specific attention was focused on the present and potential use of native woods and what could be done to encourage more complete use of the available supplies. The survey was not intended to show the total wood use on the island, as this information was already available in census reports. Construction and maintenance, although the major wood uses on the island, were not covered, as these uses require lumber and specialized products not likely to be produced in the local forests.

A brief preliminary survey of wood use on farms was conducted after the completion of the industrial survey. It showed that the forests were becoming progressively of lesser economic importance to the rural population as a result of the conditions described later in this report. However, the results of this survey are of no direct importance to industrial wood use and are not discussed further.

The information was obtained through an on-the-ground study^{1/} of more than 600 industrial plants, including those related to agriculture. The industrial card file of the Economic Development Administration of the Commonwealth was used as the initial source of a complete listing of all furniture and mill-work plants and a representative sample of manufacturers in all other branches of industry.

1/ The author was greatly assisted in this work by Raúl Ybarra Coronado Forestry Aid, Tropical Forest Research Center.

All producers of furniture and millwork were visited during the survey. In addition, five or more concerns in each of the other industrial categories, including agricultural products, were investigated. Whenever an industry was found to be using wood as a part of the product, for parts in machinery such as in textile manufacture, or for shipping containers, the survey was extended to cover all plants in the industry. This was possible as the island is of such size that it is relatively easy to determine the names and location and to contact all plants in any industrial field. All non-manufacturing wood users were also investigated, including marine terminals, shipping companies, railroads, utility services, and concerns that crate furniture and other goods for shipment.

Known or estimated wood use during the previous 12 months, costs, waste, techniques, problems, requirements, and relative information involving the use of wood were obtained from each concern. Additional observations, some planned and others unforeseen, were recorded at the time of each interview. In most industries, the initial lists of concerns supplied by the Economic Development Administration were increased by new concerns discovered during the survey.

Table 1 summarizes the wood requirements of the principal industrial users during 1954.

Table 1.—Summary of the principal industrial uses of wood in Puerto Rico during Fiscal Year 1954.^{1/}

Use	Lumber	Plywood	Number
	M. bd..ft.	M. sq. ft. ²	Each
Furniture	7,939	3,349	—
Millwork	1,657	335	—
Cross-ies	2,440	—	—
Crating & boxing	1,134	—	—
Burial boxes & caskets	450	290	—
Pallets	285	—	—
Soft drink cases	850	—	—
Utility poles	1,920 ³	—	—
Crossarms	—	—	16,200
Brackets	—	—	16,430

Use	Lumber	Plywood	Number
Fruit & Vegetable boxes	—	—	658,000
Household items	121	2,500	—
Marine repairs	160	5	—
Manufacture of stone, cement and clay products	95	—	—
Textile machine parts	—	—	29,700
Twine reels	—	—	36,000
Cigar boxes	—	—	16,800
Broom handles	—	—	880,000
Art brush handles	—	—	3,750,000
Knife cushions	—	—	9,600
Totals	17,451	6,479	

1/ Wood used in construction and maintenance, the major wood use on the island, is not included in this summary.

2/ On the basis of 1/2-inch thickness.

3/ Converted from cubic volume of 320,000 cubic feet on basis of 6 board feet equals 1 cubic foot.

THE FURNITURE INDUSTRY

Furniture manufacturing is the largest industrial use of both imported and native wood and also involves the largest number of plants and most employees of any primary wood using industry on the island. For these reasons the survey of furniture manufacturers was somewhat more detailed than that of the other industries. **First**, it was desired to make an accurate accounting of the total volume of wood used, including detailed information of the grades, sources of supply, quality, costs, and comparative utility of the various native and imported woods. This information was required primarily to determine the potential market for native woods. **Second**, to observe the operations of furniture manufacturers regarding equipment, labor, management, quality of products, seasoning, woodworking and finishings in order to determine whether better techniques could increase native wood utilization. **Third**, to determine the magnitude, causes, and character of wood waste.

There are 206 manufacturers of wooden furniture in Puerto Rico, ranging in size from one-man shops to one plant employing more than 100 people. More than 2,800 people are employed full-time in the industry. Some 178, or 82 percent of the furniture concerns employ from 1 to 24 people (see Table 2), for a total of about 1,300, or roughly 42 percent of the total number of employees in the industry. The other 18 percent of the concerns

employ about 1,500 people, or approximately 58 percent of the total number.

Table 2.—Number of furniture factories by employment size groups

Employees per factory	Number of factories	Total employees ^{1/}
Number	Number	Number
1 — 2	45	68
3 — 9	92	552
10 — 24	41	697
25 — 49	18	666
50 — 99	9	675
100 — 200	1	150
Totals	206	2,808

^{1/} Based on the median number of employees in each group.

Furniture plants are located in the metropolitan area of San Juan and in 40 other towns or cities. San Juan has 60 plants, Ponce 19, Mayaguez 14, Arecibo 13, and Aguadilla 12, with the remaining 88 concerns in smaller cities. Small and medium size plants are located throughout the island but the larger concerns are usually in or near one of the principal urban areas, where the labor supply, markets, transportation costs, and other factors are usually most favorable.

Products of the Furniture Industry

Solid wood modern furniture, upholstered furniture and china-reed furniture constitute the major portion of the output of the industry. Small quantities of combination metal and wood, rattan, rattan and wood, and native wood and reed furniture are also made, plus a relatively large volume of very low cost beds and springs. With the exception of custom made furniture, the style within each of these categories is uniform throughout the island.

Most of the small shops and some of the larger concerns do both custom work and repairing in addition to production of standard

items for the trade. A few shops specialize in custom work only but the majority find this phase of the industry insufficient and too irregular to keep their employees profitably occupied. The large plants usually accept neither custom work nor repair business.

The average employee turns out a job of as high quality as the materials and equipment will allow. His inherent reluctance to hurry and his natural pride in his work, along with the relatively simple design of most furniture results in an unusually high quality of product. Even with poorly conditioned native woods the end product is of high quality.

Many concerns produce identical items and any decline in quality of the product from one factory is readily apparent and markets are soon lost. Consequently, particular attention is given to the quality of work and the finished products.

Solid Wood Modern Furniture

Solid wood furniture with strictly modern style lines is perhaps the most popular type of furniture on the island. It may be more than coincidental that this style is also one of the easiest to fabricate, assemble and finish. Modern style furniture can also be produced in quantity with a minimum of shop equipment and if necessary by relatively inexperienced and unskilled employees.

The furniture adheres very closely to accepted modern styling, with extremely sharp, square lines, flat surfaces and an almost complete absence of any superfluous turnings, trim, or other dressings. The one exception is the four-poster bed, which has turned and often quite ornate posts. To many people this is the most charmingly designed of all Puerto Rican furniture.

Few designs are in production, making it relatively easy for the consumer to acquire matching sets of furniture from several sources. Except for minor changes, many of the smaller plants are simply reproducing furniture patterns that have been successful for other manufacturers.

China-reed Furniture

China-reed furniture is very close in popularity to modern all-wood furniture. This style is ordinarily limited to settees and straight and rocking chairs. These pieces usually have a solid wood frame and legs, with china-reed seat and backs. Occasionally reed is also used between the chair or settee arms and the seat.

This type of furniture has the same stark clean lines of modern furniture except for the reed seats and backs. It is considered low cost furniture. However, its durability and coolness probably lend more sales appeal than the usual cost of \$200 to \$250 for a four-piece group.

Upholstered Furniture

Two types of upholstered furniture are made on the island. The best of the two is the overstuffed type made by a few concerns employing a relatively small number of better-than-average craftsmen. Very good materials are generally used, including the best grades of mahogany, expensive fabrics, and usually foam rubber or coil springs. Styles are usually "borrowed" from magazines, furniture catalogs, or imported samples, with minor changes made to suit the tastes of the buyer. The finished products are of extremely high quality but are expensive.

The most popular upholstered furniture made in Puerto Rico is the plastic covered type which includes settees or davenports, rocking chairs, straight-backed easy chairs and dining or kitchen chairs. This style carries modern lines but has lightly padded seats and flat helical springs. A relatively cheap grade of plastic covering is generally used which is fairly durable in the tropical climate, cool to the occupant, and easy to clean. It is not as comfortable or attractive as overstuffed furniture but is moderately priced.

Combined Metal and Wood Furniture

A relatively small quantity of wooden furniture is made with metal tops or with iron legs. Some kitchen tables are made with

wooden legs and imported metal tops. Dining tables and chairs, coffee tables, and other miscellaneous pieces are frequently made with wooden tops and black iron legs. Living and dining room furniture of this type is made usually with a good grade mahogany.

Native Wood and Reed Furniture

(Porch Furniture)

A few small shops are producing what is locally called porch furniture. Settees, straight chairs, rocking chairs, and arm chairs are available in a style similar to that of china-reed furniture. Tabonuco or paraná pine are used for the framework. Chair rungs are usually lengths of ceboruquillo or hoja menu-da which are stripped of their bark and used without machining. The reed-type seats and backs are made of woven "pandanus" or rushes, both local products. This low cost type of furniture is usually made of green wood and poorly finished but gives good service on porches and in other exposed locations.

Rattan and Rattan-wood Furniture

Rattan furniture is made in Puerto Rico with material imported from the Philippines and Malaya. Considerable quantities or unassembled rattan furniture are also imported from the Philippines. Upholstered cushions for the back and seats are made up by the local concerns, using good quality fabrics, foam rubber, and individual coil springs. Furniture made locally is usually identical to the imported products. This type of furniture is expensive but very attractive and appears to be increasing in popularity. True rattan furniture has little if any wood visible, although some is occasionally used as supports for seat cushions. Table tops are usually either mahogany or plate glass.

Wood and rattan furniture is usually typical modern mahogany furniture trimmed with pieces of whole or split rattan. It does not appear to have the sales appeal of all-rattan pieces but does allow the manufacture of items that are either impossible or impractical to make solely of rattan. China cabinets, and buffets are typical examples,

Bed Springs and Mattresses

Large quantities of very low value beds and bed springs are made in several plants in Puerto Rico. The completed unit consists of a flat spring stretched inside a 2 x 3-inch wooden frame of pine or fir and at times a crude headboard and foot. These usually retail from about \$7.00 to \$10.00. The springs are usually sold painted but the beds are often dipped in a red stain, paint or lacquer, although no attempt is made to obtain a smooth painted surface. Several concerns use relatively small quantities of wood framing for good quality innerspring mattresses and box springs. One large concern utilizes crating material for framing their low-priced line of springs and mattresses.

Raw Materials of the Furniture Industry Volume

Nearly 8,000,000 board feet of lumber and 3,350,000 square feet of plywood and hardboard were used by the furniture industry from July 1, 1953 to June 30, 1954. (See Table 3). This includes about 2,000,000 board feet of southern yellow pine and Douglas-fir used in cheap low quality bed springs and beds and a small amount of cypress for millwork. The remainder, about 6,000,000 board feet of lumber, was used for all other furniture items. Mahogany contributes 5,244,000 board feet to this amount or more than 85 percent. Some 316,000 board feet of native lumber is included, accounting for only about 7 percent of the lumber used in furniture other than low quality springs and beds. The balance of the lumber used, some 281,000 board feet, is made up of Paraná pine, ash, oak, elm, and spruce.

The 316,000 board feet of native lumber used in fiscal year 1954 included 15 species of which 5 were predominant. Guaraguao, tabonuco, capá prieto, laurel sabino, and cedro provided more than three-quarters of all native wood. The other one-quarter was composed of laurel bobo, roble, caimitillo, nuez moscada, cilarillo, higuierillo, maga, jaguilla, laurel geo, and jagua. These 15 species were the only native woods to use, out of at least

a hundred prospective furniture woods growing on the island. Table 3 shows that guaraguao, tabonuco, and capá prieto are the most popular native woods in the furniture industry. All three are excellent cabinet woods but essentially no better than many other species available in equal or greater quantities but not yet accepted by the industry.

Relatively little furniture is made entirely of native wood as most plants use it in combination with mahogany lumber and baboen plywood. Quite frequently posts and side rails of "mahogany" beds are made of native wood. Other furniture items are often partially made of local woods in such a manner its presence is not too noticeable. Many plants use small quantities intermittently without acknowledging that their furniture is anything but solid mahogany, but the principal users are small one- to five-man shops willing to contribute the additional time and expense necessary to use native lumber successfully. The initial cost is sometimes half that of mahogany, compensating to a considerable extent for the additional difficulties in their use. Small plants also have less difficulty securing an adequate supply of perhaps 5 or 1 thousand board feet per year compared to the 100 to 200 thousand feet required by larger plants.

The average furniture plant uses about 40,000 board feet of lumber and 16,000 square feet of plywood annually. However, most plants use considerably less than this volume and a few require a much larger quantity.

Baboen, because of its low cost, has captured nearly three-quarters of the furniture plywood market, providing 2 ½ million square feet of the 3,349,000 square feet used in fiscal year 1954. The use of Honduras mahogany and cedar has declined to an estimated 562,000 square feet per year. Small amounts of okoume, African mahogany and banak are also used. Relatively small quantities of Douglas-fir plywood and masonite are used in low-cost furniture and in occasional millwork

jobs taken on by some of the small furniture plants. Yellow birch is currently the only hardwood plywood from the State in use.

Table 3.—Volume and value of lumber and plywood used during fiscal year 1954 in the furniture industry

Material	Volume	Value per M	Total value
	M units	Dollars	Dollars
Imported Lumber— bd. ft.			
Mahogany	5,244	300	1,573,200
Douglas-fir	1,525	95	144,875
Southern Pine	547	130	71,110
Paraná Pine	126	190	23,940
Ash	90	200	18,000
Elm	50	150	7,500
Cypress	26	250	6,500
Spruce	12	180	2,160
Oak	3	200	600
Totals	7,623		1,847,885
Native Lumber— bd. ft.			
Guaragua	107	135	14,445
Tabonuco	65	180	11,340
Capá prieto	47	190	8,930
Laurel sabino	24	200	4,800
Cedro	24	175	4,200
Miscellaneous ¹	51	175	8,925
Totals	316		52,640
Total all lumber	7,939		1,900,525
Plywood—Sq. ft.			
Baboen	2,499	135	337,365
Mahogany and Cedar	562	200	112,000
Douglas-fir	108	135	14,580
Okoume, banak and African mahogany	46	160	7,360
Yellow birch	20	250	5,000
Masonite ^{2/}	114	60	6,840
Total plywood	3,349		483,545
Grand Total			2,384,070

¹ Includes laurel babo, robe, caimitilla, nuez moscada, cilarilla, higuero, mago, jagui'a, laurel geo, and jaguo.
² Not a plywood but a wood product used for the same purposes.

Most plywood used is in 3/16 or 4/16-inch thickness and 3-ply. Baboen is generally used in one of these two thicknesses while mahogany is occasionally also used in 1/2-inch and 3/4-inch thickness. Douglas-fir, okoume and banak are generally used in 1/4-inch thick-

ness. Masonite is mostly used in 1/8 inch thickness and yellow birch in 7/8-inch thickness.

Small quantities of blockboard, 3/4-inch thick, are imported from Spain. The panels are made up of 5/8-inch glued strips of African mahogany with 1/8-inch 3-ply banak plywood glued to all surfaces. One factory in Puerto Rico builds up a similar blockboard, using scrap mahogany material in the core and baboen or mahogany plywood for the surface covering.

Quality of Lumber and Veneer

Mexican mahogany while not as hard, fine textured, strong, or as termite resistant as West Indies mahogany is still an excellent wood. The quality of sawn mahogany coming into Puerto Rico is fairly good, except for the frequent "breakwood" defects and soft layers which become fuzzy in machining. Boards are well sawn, uniform in dimensions, and are available in sizes up to 20 inches in width and 20 feet in length.

The southern yellow pine available in Puerto Rico is usually of poor quality. It is almost always green when received and full of defects, some already present when the lumber was sawed and other that developed during shipment and storage. The wet condition results in excessive warping, shrinkage, checking, and splitting, making it a highly unsatisfactory wood for many uses. Most of the pine used by the furniture industry is confined to low-cost beds and springs.

Paraná pine is not used extensively in the furniture industry but is far superior to southern yellow pine for most uses. It is generally dry on arrival in Puerto Rico, in excellent condition, and free of defects. Much of it is used in kitchen and reed furniture. This fine textured Brazilian softwood has good strength, works well with hand or machine tools, is reasonably stable, finishes well, and is free of pitch, but is not very resistant to termites. It is generally available in the better grades at higher prices than southern pine.

Douglas-fir sells for about the same price as southern pine but is generally of better quality and in better condition. However, nearly all of the 1-½ million board feet used annually in the furniture industry goes into low-cost beds and springs and only a very small quantity into furniture. All other imported woods and veneers are of good quality and arrive in good condition.

Although Puerto Rico's forests contain limited quantities of many fine cabinet woods, the use of native wood in furniture is decreasing rapidly due to the extremely poor condition in which it reaches the market. Native lumber generally arrives at the furniture factory a few days after the trees have been felled and the logs either pitsawn into lumber or sawed at one of the small portable sawmills. The slabs or cants are green, are not uniform in thickness, have not been edged or trimmed to even length or width dimensions, and contain all the defects originally present in the tree. The lumber is received woods-run, resulting in large differences in quality between individual boards, species, and shipments.

Great amounts of labor are involved in pitsawing. Consequently, the majority of all logs are sawn into 2-, 3-, and 4-inch cants to reduce sawing time. Except when used for bed posts, most of these cants must be resawn into ¾ or 1-inch boards at the furniture plant. This results in an added expense to the buyer, a loss in volume, and generally a further reduction in quality.

Most pitsawn lumber is carried out of the woods by men or skidded in log form by oxen. Consequently, it is difficult to secure native lumber in lengths greater than 10 feet. In addition, shipments often contain several species of different color, texture and strength properties and generally requiring different periods to air-dry. This compounds the users problems of curing and machining the local woods. Lumber air-seasoned at the furniture plants undergoes considerable warping, checking, splitting, and some insect attack. Most of this degrade could be prevented by proper manufacture and seasoning practices.

Most native wood is used long before it reaches the 14 to 18 percent air-dry equilibrium moisture content in Puerto Rico, resulting in many defects appearing in the finished furniture within a few weeks or months after manufacture.

Lumber produced by the few small portable sawmills is similar in quality and condition to pitsawn lumber except that the material is generally in longer lengths and in more acceptable thicknesses of 1, 1-½, 2, and 4 inches, according to the requirements of the purchaser. However, due to lack of edgers and cut-off saws, lumber is not cut to uniform widths or lengths.

It is not surprising that native woods are losing favor among furniture manufacturers and users when all these detrimental factors are present, even though many of the woods are themselves of excellent quality. Modern logging, milling and drying methods could eliminate most of the problems.

Plywood of mahogany and cedar is generally of very good quality and reasonably termite resistant. Baboen plywood also is of very good quality but is quite palatable to termites, a problem which is only partially overcome by chemical treatment at the time of manufacture. Okoume and banak plywood are both attractive woods of good quality but are also susceptible to termite damage.

Furniture used in Puerto Rican homes will dry to a moisture content of generally not less than 12 and more often 14 to 16 percent, as compared to 5 percent in some heated homes in the United States. Consequently, furniture shipped from Puerto Rico to the United States develops cracks, splits, and separations at glue joints as it dries out in the heated homes. This virtually eliminates any stateside market for Puerto Rican furniture until kiln-dry lumber is available. Some firms advise prospective buyers against taking Puerto Rican furniture to the States.

The increased use of air conditioning in offices and homes in Puerto Rico is causing

similar problems. Furniture dries out and develops splits and cracks in rooms dehumidified by air conditioning much the same as when shipped to the States. This condition can only be rectified by using lumber seasoned below the local equilibrium moisture content, possible only by kiln drying. Furthermore, the lumber must be used soon after kiln drying before it reabsorbs moisture and returns to the previous equilibrium moisture content.

Sources of Supply

Practically all mahogany lumber is imported direct from Mexico, with small quantities from Central and South America. Both Haiti and the Dominican Republic have banned the export of West Indies mahogany lumber or logs due to the small volume remaining. As a result, the trade is now almost entirely made up of Mexican or Honduras mahogany, which is an excellent cabinet wood but not equal to the small-leaved or West Indies mahogany of Haiti, Dominican Republic, Jamaica and other Caribbean areas. Consequently after 300 years of predominance, the West Indies mahogany has lost nearly all its former commercial importance.

As recently as 1950 Puerto Rico imported only 1,600,000 board feet of mahogany lumber, whereas the present annual rate is about 6,800,000 board feet. In 1950 and previous years mahogany importations were from Costa Rica, Cuba, Dominican Republic, Venezuela, Canal Zone, and Mexico. Mexico supplied less than half of the volume in 1950 but by 1954 furnished nearly all of the mahogany used in Puerto Rico. Small amounts of mahogany and other woods are reshipped from Puerto Rico to the Virgin Islands and possibly other Caribbean islands. Except for Paraná pine from Brazil, all other sawn lumber, used in furniture comes from the United States and Canada.

Most mahogany and cedar plywood consists of a cedar core of one or more plies covered on each side by one ply of mahogany. In numerous instances other less valuable and

less termite-resistant woods are replacing the very scarce cedar as a core stock. Okoume, one of the false mahoganies of Africa, is imported from Spain. Banak comes from Guatemala and Surinam and baboen from one plant in Surinam. Douglas-fir and yellow birch plywood and masonite hardboard are imported from the United States.

Cost of Lumber and Plywood

The retail price of mahogany lumber varies greatly by grade, the quantity purchased, and the location of the supplier. Prices are higher in Ponce and Mayaguez than in San Juan, although shipments likely come directly into all three ports. Some of the larger concerns receive shipments direct from Mexico through a local broker. However, the bulk of mahogany users buy from a few large retail yards in San Juan, Ponce, and Mayaguez. These concerns annually make thousands of sales of less than a hundred board feet, along with a relatively small number of larger sales of a truckload or more.

An average going price per thousand board feet for 4/4-inch mahogany lumber in random widths and lengths is \$360.00 for grade 1; \$290.000 for grade 2; and \$230 for grade 3. Material 8/4-inch and 16/4-inch and in wide widths is priced from \$20.00 to \$50.00 per thousand feet above these averages. Most concerns use principally No. 2 grade mahogany. The rest is mostly No. 1 grade. The largest concerns buy lumber \$20.00 to \$50.00 per thousand feet below these prices.

Southern yellow pine lumber costs from \$105.00 to \$205.00 per thousand board feet depending on grade and size. Most 4/4-inch lumber used in furniture costs about \$130.00 while 2 x 3-inch material for bed springs in 4-, 6-, and 8-foot lengths generally costs \$105.00 per thousand board feet for No. 1 grade stock. Douglas-fir of the same size and grade is imported for \$90.00 per thousand feet. Other grades and sizes of Douglas-fir range up to \$150.00 or more.

Paraná pine is available at the local yards in 4/4-inch thickness at \$155.00 to \$280.00

per thousand feet, according to grade. Ash in 4/4-inch thickness is available at \$205.00 for No. 1 grade and \$120.00 for No. 2 grade. Average prices for other kinds of lumber are listed in Table 3.

Baboen plywood has replaced mahogany and cedar principally due to its low price of about \$135.00 per thousand square feet in 1/4-inch thickness, as compared to about \$200.00 for mahogany and cedar. Large quantity purchases of baboen are usually made at a saving of from \$10.00 to \$15.00. "Spanish plywood" (okoume) is used in limited quantities at \$160.00 per thousand square feet for 1/4-inch thickness. Okoume blockboard of 13/16-inch thickness in 4 x 8-foot sheets, cost \$390.00 and 1/4-inch banak retails at about \$140.00 per thousand square feet.

Douglas-fir plywood in 1/4-inch thickness sells for about \$135.00 per thousand square feet for the interior grade and \$160.00 for water-proof-grade suitable for outdoor use. Masonite costs about \$40.00 to \$50.00 for 1/8-inch thickness, \$60.00 for 3/16-inch and \$80.00 for 1/4-inch thickness.

Prices paid for native woods vary to extremes because sales are few and each is in some respects unique. Some examples of this range (per thousand board feet) are: tabonuco \$125.00 to \$220.00 guaraguao \$100.00 to \$180.00; laurel sabino \$150.00 to \$360.00; and capá prieto \$100.00 to \$200.00. An average price for guaraguao seems to be about \$135.00 while most other species cost from \$175.00 to \$200.00 per thousand board feet. Quality or size appear to have little effect on price as native lumber is generally sold woods run.

Future Supply

The volume of native wood used in furniture has been diminishing year by year and can be expected to decline even further unless much better logging and milling practices are developed. In addition, as wages and other costs continue to rise the lumber price will also increase. Large volumes of many local species might be marketed were it not for the antiquated logging and milling practices.

All evidence indicates that local forests could supply several times the amount now being used. Consequently, the use of native lumber can either increase or decrease, depending upon technicological advancement.

Mahogany lumber is available from Mexico in large quantities at this time but recent reports indicate that this supply is not inexhaustible. Under present Mexican laws only mahogany trees over 18 inches in diameter may be cut and then only when six young trees are planted for each tree removed. Present virgin forests in Campeche and Yucatán of Southern Mexico average less than one mahogany 14 inches and over per acre. Cedar, used in mahogany-cedar plywood also occurs in very limited amounts in Mexican forests, generally not much more than an average of one tree per acre. Quite likely satisfactory substitutes will be found for the cedar as core stock. Baboen is available in large quantities, with little prospect of any scarcity within the next few years.

Douglas-fir lumber and plywood, southern yellow pine, cypress, and other woods and plywoods from the United States should continue to be available in sufficient quantities and prices to satisfy the furniture industry. Paraná pine is used principally as a substitute for southern yellow pine and is available in quantity at this time.

Rattan.—Two concerns import an estimated 730,000 lineal feet of rattan annually from Malaya, Formosa, and the Philippine Islands. This rattan comes in either preformed sections ready for use or in 13-foot lengths of various diameters, costing from 4-1/2 to 7 cents per lineal foot delivered in Puerto Rico; preformed sections ready for assembly cost somewhat more. Some of the species of rattan best suited for furniture have been planted in Puerto Rico and are apparently adaptable to the island's soil and climate. Both concerns using rattan would prefer to obtain their requirements locally if a supply becomes available as they have considerable difficulty with off grade shipments from the Orient.

China reed is imported in rolls of 100-foot lengths in $\frac{1}{4}$ or $\frac{1}{2}$ inch mesh of 12 and 14 inches width direct from Red China. It is now in short supply and high priced. One-half inch mesh now costs \$17.00 to \$19.00 per roll and quarter-inch mesh about \$22.00 per roll of 100 feet. Some importers have been unable to get shipments cleared during recent months. Hand-woven reed has been produced in Puerto Rico from native grasses but is reported to be inferior in quality and more costly than the China-reed. Nevertheless, this could be an alternative if the China supply is lost.

Other materials.—The two plants producing porch furniture use about 55,000 lineal feet of ceboruquillo and hoja menuda in 17- and 19-inch lengths and 1 to 1- $\frac{1}{2}$ inches in diameter, for chair rungs. A native reed called "enea", supplied by rural people at \$0.25 per bundle of 12-inch diameter, is braided into long rope-like strands and woven into chair backs and seats. The leaves of pandanus, an exotic plant growing in Puerto Rico, is used under the name "sabután" by one industry for room screens, lamp shades, place mats, ladies purses, baskets, and many other items. Locally grown bamboo is used by two concerns for lamps, vases, toys, and hot pads and to a limited extent for furniture. One concern produces its own supply; the other purchases it for about one cent per lineal foot.

Problems of the Furniture Industry

The importance of the furniture industry as a wood user and a source of local employment makes it especially desirable that this industry be kept healthy. Inefficiencies of this industry which result in high prices or poor quality of product constitute handicaps to forestry through the limited markets for forest products which result. For this reason a special study of these problems was included in the survey.

As in many industries marketing is the major problem of the furniture industry. There are too many furniture plants in Puerto Rico. Consequently, most plants are unable to operate at full capacity, meaning

periods of unemployment, running with a reduced crew or underselling with reduced profit to keep in operation. Perhaps one-half to two-thirds of the present productive capacity could meet the demand for furniture in Puerto Rico.

Costs are rising for both labor and for materials, particularly mahogany and plywood. Popular demand for termite resistant woods has forced producers to the almost exclusive use of mahogany or wood that appears like mahogany to the buyers. Most available substitutes for mahogany are not termite resistant and when evident are rejected by the consumer who is also presently objecting to the high furniture prices. However, these costs are partially the result of heavy retail mark-ups.

Most small plants are poorly financed and are unable to buy lumber in quantities large enough to warrant reduced prices. They are also unable to stock any quantity of furniture for future sales but must move their products weekly to meet current expenses.

Technical Problems

Lumber Storage and Drying

Good principles of storage or drying of lumber are not followed and apparently are understood in only a few, if any, of the furniture plants of Puerto Rico. Many of the small plants buy imported lumber in such small quantities that storage is not a problem. But the larger plants, stockpiling up to a 3-month supply, generally have a high loss in grade and volume due to slipshod methods of piling and storage.

Most mahogany arrives in need of additional drying. Small concerns generally use their supplies up within a week and consequently are not concerned with storage, although their products may not be entirely dry. Larger concerns buy less frequently and are aware of the need for drying mahogany, pine, and fir but seldom pile or store it in a way that this can be accomplished.

Most imported lumber is piled under cover, sometimes on special racks but more often on a concrete floor and occasionally on the ground. Often it is simply thrown in a loose pile. Stickers are almost never used, even when lumber is carefully piled on racks or in rooms reserved for drying. This tight piling, without stickers, lacks the necessary air movement to allow drying but does prevent degrade from warping.

Some of the larger concerns pile mahogany lumber in loose piles outdoors without roofs or protection of any kind and without stickers except occasional 4 and 6-inch mahogany boards used as "self-stickers". These concerns admit the occurrence of much warping, checking, and end splitting but give special care to the lumber when it is used to minimize these defects. One concern soaks mahogany lumber after storage to reduce the cupping and other drying defects resulting from poor piling.

Another concern stores mahogany lumber for 2 years in a specially constructed drying shed. The lumber is well piled on racks but is largely without stickers. No ventilation is provided in the building holding up to 100,000 board feet of mahogany of 1- to 4-inch thickness. Relatively little drying is possible under these conditions. Fortunately mahogany is a stable wood that does not swell, shrink, or warp readily and stays in reasonably good condition when abused.

Some native lumber is purchased partially air-dry from the logger but most is received at the plants in small lots soon after sawing. The few plants still buying logs allow them to air-dry for 6 months to a year. However, most native lumber is purchased in 1- to 4-inch cants which are either used immediately or allowed to air-dry in tight stacks from 1 to 24 months, most being used within 6 months. Green lumber is also occasionally cut into rough furniture blanks and allowed to air-dry in tightly piled stacks for 30 to 90 days before machining and assembly.

Native wood is sometimes stood on end against a wall to dry but more often is flat piled in tight piles on the floor, on rack, or

sometimes outdoors without the benefit of stickers. Fortunately, the rough lumber surfaces and odd widths create some openings in the tightly piled lumber, thereby providing limited air movement for drying. Checks, splits, and other defects are common, in fact so common that it is difficult to select a board without at least one serious seasoning defect. Borers often penetrate the sapwood of some species soon after piling and termite damage is not uncommon. Roofs or other coverings are seldom used over outdoor piles.

It is apparent that native lumber is seldom air dry when used. The numerous customer complaints of splits and cracks in native wood furniture justify the refusal by many concerns to use it. Most furniture species are dense, heavy, slow drying woods that are virtually impossible to air-dry by present techniques. Dry kilns are the eventual solution. However, proper piling with stickers, strong elevated pile foundations and protection from the weather would eliminate most of the difficulties.

Protection Against Insects

None of the hardwood lumber and only a very small portion of softwood lumber used in furniture is treated with a preservative to prevent damage by dry-wood termites and other insects. However, all rattan used in furniture is treated.

Pentachlorophenol solutions are occasionally brushed on softwood lumber. Rattan is treated by dipping in a 5-percent "penta" solution or by pouring the solution on one end of the rattan poles. A small quantity of preservative poured on one end of a 13-foot rattan pole will flow to the other end in a matter of minutes.

With the exception of mahogany and cedar lumber and plywood, all imported woods are readily susceptible to termite attack. Baboen is guaranteed as having been treated against insect attack but is still very susceptible to termites according to recent tests carried out by G. N. Wolcott of the Agricultural Experiment Station of the University of Puerto Rico. Among the more

popular native furniture woods only maga, guaraguao, capá prieto, and cedro have good resistance to termites, maga being the most resistant but available only in small quantities. All other imported and native woods used by the industry are rated as having poor to moderate resistance to termites.

Even though large quantities of wood of low to medium termite resistance are used in furniture it is apparent that most furniture is worn out or outdated before it succumbs to termite damage. Furniture of very susceptible woods often endure 10 to 15 years of service without visible evidence of termite attack. However, under extreme conditions termites can destroy a house full of furniture in a short time.

There is little excuse for failing to treat native wood used in furniture as a simple 3-minute dip in a "penta" solution will protect most woods.

Gluing

Wood gluing is not difficult in Puerto Rico as the high relative humidity prevents both the glue joint and wood from excessive desiccation. Urea-formaldehyde glue and casein glues are the most used. Urea-formaldehyde glue is used by most concerns in the more humid areas of the island and casein glues in the less humid regions along the south coast. The first named is preferred in the most humid areas because it does not absorb moisture as rapidly as the casein and some other synthetic resin glues. Polyvinyl resin and urea resin glues are also used with success. A synthetic resin glue is made locally and appears to be gaining in popularity.

Finishing

Modern finishing methods were not seen in any of Puerto Rico's furniture plants. All finishes are applied by air-operated hand-spray guns except for a few small shops still using brushes. Baking ovens or other heat treatments used in modern finishing techniques, are not used although one large concern is using heated lacquer.

A more or less standard finishing technique has been developed over the years which gives an exceptionally attractive finish but is too soft to withstand the abuse of normal use. The relatively heavy layer of soft lacquer is easily scratched, marred, or dented despite its very attractive glass-like appearance. Water and heat also damage the surfaces rather quickly.

Most good quality furniture is finished light or natural, requiring only a very light stain, or no stain at all. Native wood is generally stained dark to imitate dark mahogany.

Most plants have a separate room reserved for finishing and in some places a separate building. Many are without exhaust fans of any sort and only a very few have spray booths. A part of the small shops and even some of the larger ones do all or part of their finishing over dirt floor and very often their paint rooms or the areas designated for painting are subject to dust from nearby machines. Nevertheless, the work is relatively free of dust and blemishes and of a good quality as can be expected with the materials and techniques applied.

Wood Residue

Wood residue is an important cost factor in an industry using material valued at \$200 to \$300 or more per thousand board feet. The amount of wood residue in furniture manufacture is not alarming but the waste pile can, and often does, consume the normal profit of a furniture plant. Throughout the survey it was evident that the plants with an abnormally high proportion of wood residue were also the least profitable. Concerns that had failed almost always left a huge mound of residue containing sufficient value to meet their payroll for many days.

A majority of the furniture concerns are unaware of the amount of wood residue except that residue woods is about twice that of mahogany. Estimates made by the management of 149 concerns showed an average of wood residue of 14 percent for imported

hardwood lumber and plywood, including principally mahogany, baboen, and cedar. Estimates for native wood residue averaged 24 percent in 28 plants. The loss in pine and fir was estimated at 12 percent in 20 plants furnishing this information.

On the basis of these composite estimates the annual volume of wood residue in the furniture industry amounts to nearly 740,000 board feet of mahogany and other hardwoods, over 260,000 board feet of pine and fir, more than 450,000 square feet of plywood and approximately 80,000 board feet of native lumber.

Wood residue occurs principally in pieces of solid wood of varying sizes or shapes and as sawdust and shavings. The balk occurs in the form of blocks and squares of solid wood ranging from the size of a domino to blocks several inches wide and 3 or 4 feet long. Sawdust and shaving make up a minor portion of the loss. As a rule, the pieces in the waste pile increase in size at about the same rate as the proportion of waste.

Most loss occurs during the initial cutting of boards into the individual blanks or pieces for different furniture parts. Part of this loss is due to cutting out visible defects, some from invisible defects that are discovered after cutting or planing, but likely the greatest loss occurs as board-ends or cut-offs. Part of this is due to checks, splits, cracks and other degrade occurring in lumber during storage or as a result of rough handling.

The general practice is to cut out one size furniture blank at a time. This system seldom utilizes the full length or width of the boards. When one or more defects have to be cut out the unused portion is increased due to the inflexibility of the cutting procedure. Some of the larger pieces are retrieved later from the trash pile but not to any great extent, as the labor cost is often greater than the savings. However, it is much more practical to prevent or reduce loss in this manner than to make use of residue material after it accumulates.

Plants operating on a piece-work basis generally have a greater rate of wood residue than normal due to the reluctance of workers to reduce their productivity in order to save material costs for the management. Some plants also increase wood residue by improper storage of lumber before use. Relatively little material develops defects or is broken or damaged beyond repair during fabrication.

Native wood residue is high due to the hidden and visible defects that are present on purchase, defects that occur during seasoning and storage, lack of uniformity in length, width and thickness, loss in resawing into usable sizes and insect damage.

Wood residue can be reduced in the following ways:

1. Store and dry lumber under cover with proper care to prevent degrade during storage.
2. Plane all boards before cutting into furniture blanks so that all defects are visible.
3. Train workers to break down each board into the sizes or blanks which will most nearly utilize the entire piece. This means that the saw operator must either carry in his mind or have immediately available a list of the various size blanks required by the plant. He can still plan the cutting to produce as many blanks of the size desired at the time but should cut out other size blanks whenever it would reduce waste. These extra blanks should be properly stored until used.
4. Use furniture designs which utilize short material and small pieces normally lost as waste.
5. Prepare or use furniture designs that will allow the breaking down of plywood and lumber with the least possible waste.
6. Design and manufacture small household, novelty or other items which use principally narrow or short pieces of wood normally found in the trash pile.

Numerous uses are made of wood residue but most plants have no organized program for its utilization. Some is furnished to schools for student use, much is given to local hobbyists and small quantities are made into household items, but the bulk is dumped as refuse.

The larger plants usually make less use of their wood residue than the small concerns; they produce limited amounts of picture frames, trays, shadow boxes, book-ends, handbags, wall shelves, lamps, plates, bowls, paper weights and other novelty items. Picture frames seem to be especially popular. Most concerns also make enough dowlings out of mahogany scraps to satisfy their own needs. One concern sells mahogany cutoffs to a local manufacturer of souvenirs.

One large plant has \$8,000 worth of equipment to convert mahogany residue into block-board. Mahogany scraps are sanded, sized, and glued into 4 x 8 foot-panels, 3/4-inch thick. One-eight inch mahogany veneer is glued to each side to make a 1-inch block-board panel which is used in furniture. The firm estimates total costs amount to 8 to 9 cents per square foot, assuming the scrap mahogany valueless.

Souvenirs and other items made of mahogany residue are marketed in competition with similar items imported from Haiti. However, Puerto Rico concerns pay much higher wages than those in Haiti and, therefore, are unable to compete unless they have the advantage of modern specialized equipment. It appears that plants equipped with machinery adapted to the manufacture of novelties and other tourist items could compete successfully with Haitian products until such time as they also mechanize their operations.

Problems of Management

Facilities

Most small furniture plants and many of the larger plants occupy buildings originally constructed for other purposes. They are generally too small, poorly lighted, lacking in ventilation, and not well adapted for furniture

manufacture. Some are two- or three-story structures with narrow winding stairways. Some concerns occupy two or three buildings, often reserving one exclusively for finishing. Sanitary facilities and other equipment essential for the health, comfort, and safety of the workers are usually lacking.

Rarely are the buildings large enough to adequately accommodate the employees, machines, and materials or to store finished furniture. Plants are located in basements, under galvanized roofs supported by poles, in attics, garages, or on the first or second floor of homes or buildings housing other business concerns. There are, however, a few plants housed in new, well constructed buildings entirely suitable for the work.

Inasmuch as most furniture plants are very small it is not surprising that their wood-working machines are usually of hobby-shop size. Even the larger plants use these small machines for most operations. Despite their low initial cost, these machines are not economical to use in production work, due to their size, insufficient power, and the close attention necessary to produce satisfactory work. This is the principal reason why the production rate is exceedingly low in Puerto Rico's furniture plants.

The typical small or medium size furniture plant employing three or more people has a 12 x 4-inch one surface planer (\$55 to \$750), 12-inch radial saw (\$400 to \$500), 10-inch table saw (\$300.00 to \$350.00), 12-inch band saw (\$300 to \$500), 6-inch jointer (\$250 to \$350), occasionally a single spindle shaper (\$250 to \$400), hand-operated electric belt sander (less than \$100), 1/4-inch table-model electric drill press (less than \$100), and a 12-inch lathe (\$200 to \$300). A few better equipped plants have small electric belt sanders and occasionally small mortising and tenoning machines. Home made jig saws, table saws, lathes, and bandsaws are not uncommon in the smaller shops. A number of large size, heavy duty but old and obsolete machines are used in the small concerns. The several large plants have a few

heavy duty machines suitable for sustained low cost production, including heavy duty automatic lathes, drum sanders, belt sanders, and rip and trim saws. A large proportion of the machines have been purchased new within the past 3 or 4 years. Much work is still done with hand tools and hand planing and sanding is still very common.

Most woodworking equipment is kept in reasonably good repair. Saw teeth and cutting knives used in the machines and hand tools are reasonably well maintained in comparison to the deplorable standard of housekeeping in most of the plants. However, many concerns would have trouble machining woods of greater density than mahogany, one of the easiest woods to machine.

Organization

Faulty management practices are often an important factor in the lack of efficiency among the furniture plants. Often the owner's inexperience is a primary cause of inefficiency in the smaller plants. However, the failure of management to supervise employees or to hire or delegate supervision is the most frequent weakness in management. It is not infrequent to find plants where the only supervision is provided by one or two daily visits by the owner. More often one man acting as the foreman, manager, and owner of a plant having up to 50 employees can be located only in the front office deep in the midst of important business affairs. His apparent economy in not hiring at least one supervisor prevents efficient operation as most employees do not have the experience, desire, or privilege to organize the work for greater efficiency and production. When foremen or supervisors are employed they often assign sufficient machine work to leave little time for direct supervision; others have no authority to plan or organize the work. By and large, it is evident that nearly every furniture plant in Puerto Rico could be operated more efficiently under better management practices.

Labor

All employees in the Puerto Rico furniture plants are male, except for an occasion-

al office girl in the larger plants. With few exceptions, they are reported to be steady, reliable, and willing workers. Many of them have no previous experience on any type of factory machines but possess the infinite patience necessary to do high quality work on small machines or with hand tools. Most employees are not efficient and produce a relatively low output per man-hour, due in most instances to a lack of training, under-sized equipment, inadequate supervision and poor management.

Most employees are not specialized but can handle any of the jobs in furniture manufacture except finishing. Generally one or two men, often the owner or manager, does the finishing work except for sanding and hand rubbing; this is usually done by the least experienced and lowest paid employees, often youngsters of school age.

There is a continual loss of the most skilled and ambitious workers to the United States where their training and desire to work is in demand. Local industry cannot compete with wages in the States and can do little to hold these better men, who sometimes return to establish a new plant in competition with their earlier employer.

Problems of Marketing

There is no evidence of any active island-wide organization of furniture manufacture of the type operating in the United States which aids members in purchase of materials and sale of products. Each plant buys, manufactures, and sells independently. Many plants are owned in conjunction with one or more retail furniture outlets and thereby have a steady market for their products. Others must sell on the open market to retail stores within their area, generally in competition with several other producers. Furniture is not shipped to the States or other islands in the Caribbean.

There appears to be little specialization in the industry, each plant generally producing a full line of furniture according to the market demands. This eliminates any chance of

specialized equipment or skills in a small plant. It appears that marketing might eventually be easier for the plants specializing in one or two items, as production costs could be lowered and quality increased. This should bring more advantageous marketing conditions although the marketing area might have to be greater.

Recommendations Leading to Better Furniture Wood Utilization

The survey of furniture manufacturing in Puerto Rico reveals some problems and to some extent their apparent solutions that should be recognized and acted on for the betterment of the industry in particular and the forest industry in general. The more important recommendations follow:

Application of Existing Knowledge

1. Replace the present antiquated logging system with the use of double-bit axes, crosscut saws, chain saws, crawler tractors, and self-loading trucks.
2. Eliminate the necessity of whipsawing lumber by establishing one or more well equipped modern circular sawmills, edgers, and planers which are on the market today.
3. Establish at least one large commercial type dry kiln in the metropolitan area and possibly several low cost portable crop-drier type kilns at other locations.
4. Establish at least one pressure treating plant and promote the use of dipping tanks by individual concerns to render wood unpalatable to insects.
5. Make full use of local woods suited for furniture manufacture.
6. Pile and season woods properly before use, thereby improving the quality of product.
7. Use more supervision and planning in furniture plants.
8. Construct adequate housing for furniture plants.
9. Practice better housekeeping by removing sawdust, shavings, and scrap

material daily to allow efficient use of available space.

10. Specialize plant operation to a greater degree to increase efficiency, reduce costs, and improve quality.
11. Introduce better furniture designs to meet the changing markets.
12. Acquire bigger, better, and more specialized factory equipment to reduce costs and increase quality.
13. Train employees how to break down planed boards with the least possible loss.
14. Train employees for specialized jobs to promote more efficiency and skill in each phase of furniture manufacture.
15. Adopt modern finishing techniques that are less time consuming and give more durable finish.
16. Promote the acceptance by the public of species other than mahogany in anticipation of the not too distant time when mahogany will become too costly and scarce to be used in moderate priced furniture.
17. Substitute treated native hardwood for mahogany in concealed places where no loss in beauty is involved.

Research

1. Determine most economical logging methods.
2. Complete studies of physical and machining properties of native woods to determine their utility for furniture manufacture.
3. Adopt air and kiln drying techniques for local woods.
4. Perfect preservative treatment techniques for native lumber in storage and for furniture made there from.
5. Develop new uses for wood residues from furniture plants.

MILLWORK

Millwork plants in Puerto Rico manufacture principally doors and windows and the frames to hold them, plus lesser quantities of louvers, blinds, and specialized custom items for private and commercial structures.

Wooden doors are still standard items but the wood in windows, blinds, and other products is being replaced by metal and glass which are considered to be more hurricane resistant and, of course, not subject to insect damage. However, oxidization and rust limit the life of metal windows, somewhat as decay does to wood.

There are 38 plants principally engaged in millwork in Puerto Rico. Fifteen of these plants are located in the San Juan metropolitan area, five in Ponce, and the rest are scattered throughout the island. Two plants in the metropolitan area produce more than the other 36 plants combined. Many furniture furniture industry are also producing millwork in addition to furniture. The 38 plants specializing in millwork employ about 300 people. Perhaps another 50 employees in the furniture industry are also producing millwork on a year-long basis.

Millwork requires relatively large quantities of wood of a better quality than that used in many other industries. The industry used an estimated 1,657,000 board feet of lumber and 335,000 square feet of veneer, valued at \$382,000, during fiscal year 1954 (Table 4). Second-growth southern yellow pine, although inferior to redwood, cypress or mahogany comprised nearly three-quarters of the lumber used in millwork.

Dense, pitchy yellow pine was available in Puerto Rico for many years. It was highly resistant to termites due to its high pitch content and, consequently, became a preferred wood for millwork and many other uses. When the supply of old growth pine was exhausted, second-growth yellow pine took its place. The second-growth material has neither the density or pitchiness of the earlier wood, is inferior in strength, and more subject to excessive and irregular shrinkage and warping. However, its relatively low-price and the century-old custom of use keeps southern pine as the most popular softwood in the island. Most larger plants buy kiln-dried yellow pine in the upper grades and maho-

gany and cypress that have been air-dried one year or more. Douglas-fir is superior to yellow pine in some qualities but has never gained the popularity of pine for millwork, construction, and other uses.

Table 4.—Volume and value of lumber and plywood used during fiscal year 1954 in the millwork industry

Material	Unit value	Total value
	Dollars	Dollars
Lumber-M bd. ft.		
Mahogany	295	47,790
Southern pine	160	183,680
Douglas-fir	150	2,400
Red cedar	130	13,000
Redwood	290	3,190
Cypress	295	63,130
Paraná pine	190	1,140
Totals		314,330
Plywood-M sq. ft.		
Baboen	135	17,145
Mahogany & cedar	200	8,400
Douglas-fir	135	21,060
Okoume and banak	160	1,600
Totals		48,205
Total value		362,535

Cypress heartwood is the most termite resistant wood available for millwork but material now available generally contains a high percentage of sapwood which is low in resistance to termites. According to studies by G. N. Wolcott, the heartwood of redwood, southern pine, Douglas-fir, and Honduras mahogany have similar termite resistance, with mahogany being slightly better than the others. Red cedar rates below the other woods, and cypress considerably higher. The high percentage of heartwood in shipments of mahogany and redwood make them preferable species where termite resistance is important,

as Douglas-fir and southern yellow pine generally have a high proportion of sapwood. African and Philippine mahogany (any one of several species) are generally more vulnerable to insect attack than these species.

Red cedar wood is light and soft, and is generally not considered good for millwork but may be suitable for blinds and other similar uses where strength and nail holding properties are not important. It is very resistant to decay, easily worked and does not warp or check readily. It is inferior to redwood in some ways but is generally a satisfactory substitute for that species.

Baboen and Douglas-fir plywood make up about 85 per cent of the plywood used in millwork, with Douglas-fir the favorite. Both species cost about \$135 per thousand board feet in 1/4-inch thickness. Small quantities of mahogany and cedar plywood are used plus minor amounts of okoume and banak. Native woods are not used in millwork except on infrequent occasions by small furniture shops.

The two largest millwork plants give most of their material a 3-minute bath in a 5-percent pentachlorophenol and mineral spirits solution. Other plants apply one application of 5-percent "penta" solution with a brush or by 1- to 3-minute dip when specified by the purchaser. Most of the smaller concerns treat only a small portion of their output.

It appears that the public is unaware of the benefits of preservative treatment and thus does not usually require treated wood in millwork. There is some doubt as to the value of treatments where the soaking period may be reduced to less than a minute or when treated material is sanded, planed, or recut after treatment. It also appears that the benefit of a 3 minute soaking is soon lost when material is used in locations exposed to the elements, as "penta" tends to leach out.

Specialized machinery, including mortise and tenoning machines is used to some extent in the bigger plants, but small shops still use hobby-size wood-working machines. Labor appears to be skilled and more specialized than in the furniture industry and as pro-

ductive as possible with the equipment provided. All small shops and most of the large shops still use hand tools for some phases of the work. Much hand planing and sanding is done in even the largest shops. Several different glues are being used with good results, including urea-formaldehyde, urea-resin, and casein-resin glues.

The estimated average wood amount of residue left after manufacture amounts to 14 percent for the entire industry, ranging from a low of 5 percent up to 20 percent. The two largest concerns estimate their loss in unused material at 10 and 15 percent respectively. Most residue is in the form of cutoffs although some results from defective material, principally in yellow pine.

Recommendations Leading to Better Wood Utilization in the Millwork Industry

Metal windows and other millwork items are increasing in popularity at the expense of similar wooden items. If the producers of wood windows and other wooden millwork products are to hold their present share of the market or to regain a portion of their former market it will be necessary to build attractive, decay- and insect-resistant items that sell at prices substantially below those for similar metal products. Changes are also required in many plants to compete price-wise in the imported panel door market. The following suggestions are offered as a partial means to meet this problem.

1. Provide more and better supervision and planning.
2. Provide better working conditions by increasing plant size, better house-keeping and more orderly flow of materials.
3. Use larger, more productive and accurate machines specialized for the different millwork operations.
4. Eliminate insofar as possible all hand work, such as sanding, planing, and nailing, which can be done by machines.
5. Standardize sizes of products and promote their use by all builders.

6. Encourage specialization of employees to increase production.
7. Use only pressure treated lumber, or thoroughly treat all completed items to withstand insects and decay.

FRUIT AND VEGETABLE CONTAINERS

With the exception of cigars and household goods, fruits and vegetables are the only products exported from Puerto Rico which require any appreciable quantity of wood for shipping containers. More than 650,000 wooden fruit and vegetable containers of all types were used during fiscal year 1954 (Table 5) at a total cost, including freight, of over \$300,000.

The pineapple industry was the largest user, purchasing an estimated 390,000 3-cubic foot size wooden crates during fiscal year 1954. This number included 27,000 units used only for field crates. Another 6,900 specifically designed field crates were also purchased by the industry. All pineapples are shipped in new crates.

Table 5.—Wood field crates and shipping containers used for fruits and vegetables during fiscal year 1954

Container type	Quantity used annually	Cost per unit including freight	Total cost annually, including freight
	Number	Dollars	Dollars
Pineapple crates 3.0-cubic feet ^{1/}	390,000 ^{1/}	0.58	226,200
Banana boxes ^{2/} 32 x 12 x 13 inches	2,000	1.80	3,800
Mango crates ^{3/} wire-bound 4/5-bushel	27,000	.60	16,200
Used wire-bound crates ^{3/} 4/5, 1, 1-1/9, 1-1/5-bu.	322,000	.22	51,040
Field crates ^{2/} 20 x 14 12 inches	6,900	1.20	8,280
Total	657,900		305,520

^{1/} Includes 27,000 used for field crates only. Data from Department of Agriculture and Commerce, with estimate of value exported in June and July, 1954.

^{2/} Data obtained by field contacts.

^{3/} All exports of fruits and vegetables except piñas and mangos are packed in used containers. Data from Survey of Packaging and Shipping Containers by Economic Development Administration, reports from the Bureau of Production and Marketing, and field contacts during the course of the survey.

All other fruits and vegetables except mangos are shipped in used wire-bound crates of 4/5- 1½, and 1-1/5 bushed capacity. Some

232,000 used wire-bound crates are estimated to have been purchased for this purpose in fiscal year 1954 plus 27,000 new 4/5-bushel wire-bound crates for mangos. Bananas are not expected but about 2,000 boxes are purchased annually for local use.

Pineapple crates cost about 59 cents each delivered. Banana boxes (32 x 12 x 13 inches) made of cottonwood and black gum cost about \$1.80 delivered. Field crates (20 x 14 x 12 inches) made of kiln-dried gum or cottonwood are worth about \$1.20 delivered and new 4/5-bushel wire-bound crates for mangos sell for around 60 cents delivered. Used wire-bound crates cost from 13 to 19 cents each, plus about 6 cents freight, averaging about 22 cents on the basis of the present distribution of sizes.

All pineapple crates, field crates and banana boxes are purchased as box shook and assembled in Puerto Rico at a cost of from 7 to 10 cents each. Wire-bound crates are received assembled in the flat "knockdown" condition but are easily set up by crimping the extended wire attached to both ends of each crate at an assembly cost of perhaps 2 or 3 cents per crate.

Export shipments of fruits and vegetables are increasing annually. In addition, government agencies are endeavoring to have all shipments made in new crates. This program will not necessarily increase the total requirements for wire-bound crates but will triple the expenditure for them, adding nearly \$100,000 to the annual cost for this type of container.

There appears to be no prospect of an immediate change in the type of crates used for shipments of vegetables and fruit out of Puerto Rico although paperboard and fiberboard are replacing wood in many types of fruit and vegetable containers in the United States. In time, some shipments may be in fiberboard or paperboard boxes reinforced with wood. In the long run it is likely that the use of wooden crates will increase, perhaps even double, but may eventually be partially replaced by paperboard and fiberboard boxes.

Recommendations which might lead to local wood use for fruits and vegetable containers include the following:

1. Set up a modern box plant in Puerto Rico using imported and native woods. The advantage of very favorable labor, climate, a steady local market for fruit and vegetable containers, plus the expected increase in demand should provide an attractive base for a new industry.
2. Eliminate the use of used wooden containers for export shipments to enhance the appearance of the product.
3. Standardize types and sizes of containers to the minimum number possible.

SOFT DRINK CASES

The only extensive local use of wooden containers by the food and drink industry is for soft-drink cases. All other products are transported locally in reused containers, paper containers, or in bulk. A survey of the 19 soft drink manufacturers, plus their outlying bottling plants, showed an estimated annual use of 171,500 wooden cases at a cost of \$177,380. The smallest plant uses only 500 boxes and the largest about 35,000 boxes annually with the average plant requiring over 9,000 new cases per year. Assuming each box contains five board feet of wood, a total of more than 850,000 board feet is required annually for replacement and repair by the soft drink companies operating in Puerto Rico.

Most boxes are imported in shook form and assembled locally. Box shook costs about 90 cents, transportation 8 cents, and assembly 5 cents, for a total assembled cost of \$1.03 each. All box shook is assembled by hand nailing with special rustproof nails and metal strapping furnished with the shook. Bottles are usually purchased locally but when imported are shipped to units of 24 bottles,

covered top and bottom by assembled cases. The assembled cases protect bottles from breakage, eliminate packaging and reduce shipping costs for the complete units. Most concerns use a considerable proportion of their imports of box shook to repair their present supply and boxes. Several small shops have made a limited number of soft drink cases without much success. One concern used plywood and yellow pine which gave poor service while the others failed to standardize the size of the boxes, most boxes being too roomy to hold bottles snugly. All imported box shook for soft drink cases is either cottonwood or black gum. Cottonwood is the better of the two species and fortunately makes up most of the volume imported. It makes a light, strong, white box that is free of defects and can be assembled easily without splitting or other difficulties.

Soft drink cases last from 1 to 2 years under Puerto Rican conditions as all box shook is received untreated and consequently is very vulnerable to decay and insects. Decay, breakage, loosening of nails and termites are the principal causes of box failure. The majority of small retailers misuse empty and often full cases by storing them outdoors subject to the elements and by using them as bases for displays or storage of food items. This misuse and rough handling by delivery men are largely responsible for breakage and nail loosening. Some failures are due to faulty installation of the metal strapping which binds both ends of each box.

Service life of cases could be increased if special equipment were available for this purpose. Two concerns are dipping bundles of box shook in "penta" solutions before assembly. Some benefits accrue but as the bundles are bound tightly by metal bands there is virtually no movement of the preservative into the interior of the bundles. The average life of boxes might be doubled if all material was soaked in a 5 percent pentachlorophenol or other preservative in such a manner that each piece receives treatment. Cottonwood and

gum should absorb enough preservative to resist rot and insects for several years.

Box shooks for soft drink cases could be made in Puerto Rico. Several local woods in fair supply appear to qualify for this use. If they can be converted into lumber at prices comparable to cottonwood and gum it is reasonable to expect a box plant would be feasible in Puerto Rico. Large quantities of soft drink cases are also used in Central and South America and other Caribbean Islands which are within the marketing area of a Puerto Rico plant. In addition, there are other types of boxes and containers in heavy demand in Puerto Rico which could be made by the same concern. Most soft drink bottlers expressed a willingness to buy boxes locally if they were of comparable quality and price to those being imported from the United States.

UTILITY POLES

Public utility services are provided by one private concern, the Porto Rico Telephone Company, and two public corporations, the Communications Authority and the Water Resources Authority. Two business houses import poles and accessories for sale to non-government users. Tables 6 and 7 show the total use by private and public agencies of

poles, crossarms and brackets for fiscal year 1954, including data for the Porto Rico Telephone Company adjusted from a calendar year to fiscal year basis.

Nearly 17,000 utility poles of all lengths and classes, amounting to 320,000 cubic feet, were used during fiscal year 1954 at a total cost of about \$645,000. In addition, more than 16,000 crossarms and over 16,000 brackets and pins valued at \$46,000 were used during the same period. Thus the total value of all wooden utility materials amounted to about \$690,000 during that year. All poles are pressure-creosoted southern yellow pine. Average cost per pole delivered in Puerto Rico varies from \$12 for 25-foot lengths to \$145 for 60-foot poles, averaging \$38 for all poles used during the year. More than one-third of the use was in class 2 poles of lengths from 25 to 60 feet (pole class numbers decrease as the pole diameter increases, hence class 2 poles are larger than class 3 poles, etc.), and nearly 70 percent of all poles were in class 2 or 4. Crossarms, pins, and brackets of various sizes are also all pressure treated with creosote preservatives. All crossarms are southern yellow pine and pins and brackets are usually oak or southern pine.

Table 6.—Annual use of utility poles in Puerto Rico

Length (feet)	Pole class							Total	Cost Total
	2	3	4	5	6	7	9		
	Number							Number	Dollars
25	—	—	—	400	20	960	200	1,580	18,800
30	2,430	—	2,000	1,170	—	360	1,210	7,170	202,400
35	2,490	20	2,040	400	40	100	—	5,090	202,800
40	460	—	1,010	50	—	—	—	1,520	69,700
45	320	500	—	—	—	60	—	870	60,200
50	30	—	—	—	—	—	—	30	2,400
55	560	—	—	—	—	—	—	560	67,700
60	140	—	—	—	—	—	—	140	20,600
Totals	6,430	520	5,050	2,020	60	1,470	1,410	16,960	644,600

It appears that there are reasonably good opportunities of producing and treating poles in Puerto Rico. Sufficient Australian pine, eucalyptus and possibly other species could be produced to meet the needs for all classes of poles in the 25- to 40-foot lengths, which serve most of the pole requirements. This would of course require the establishment of a pressure treating plant of sufficient size to handle 40 foot poles, and tests would be required to determine if local woods are as strong and durable and can be treated as successfully as yellow pine. The high costs of handling and shipping creosote treated poles, partially due to the fire hazard with creosoted material, would give economic advantages to local pole producers. However, utility companies cannot be expected to use local products unless they are at least equal in quality and comparable in price to southern pine. Lower quality poles, even if at less cost, would not be attractive due to the more frequent installation and maintenance cost and the attending disruption of services.

There are possibilities of savings by treating poles and other items after delivery in Puerto Rico if a pressure treating plant were established. Large quantities of preservatives are used in treating poles and ties. Preser-

vative treatment of the 17,000 utility poles used annually in Puerto Rico would require at least 3,200,000 pounds (400,000 gallons) of preservative solution.

CROSSTIES

Crossties are used by sugar companies and the common-carrier railroads in Puerto Rico. A number of the sugar companies have either removed or reduced their trackage during the last few years and substituted trucks, farm tractors and rubber-tired carts to move cane from the fields to the mill. Despite the reduction in trackage, large quantities of ties are still used. During 1953 a total of 129,500 ties (2,840 M board feet), valued at \$350,000 were required for track maintenance. Some 87,700 creosoted southern yellow pine and 18,700 untreated cypress ties were imported from the United States. Another 8,000 hardwood ties (190 M board feet) came from the Dominican Republic and 15,100 (280 M board feet) were from the local forests. (see table 8).

Ties imported from the Dominican Republic by four sugar companies were principally candelón and bayahonda, plus a small number of quiebrahacha. Apparently only hewn ties are available, priced at \$2.00 CIF San Juan for ties hewn on two sides and about \$3.50 for ties hewn on four sides. All were 6 x 8 x 72 inches in dimension and untreated.

Native ties were used by sugar companies with three concerns using more than 90 percent of the total. Most native ties were 6 x 8 x 72 inches in size with some 6 x 6 inch, 5 x 5-inch, and 8 x 8-inch sizes used in 60 and 72-inch lengths. Species used include tortugo, capá blanco, cedro macho, roble, maría, moralón, and ucar. The sugar companies generally specify whether the ties are to be hewn on two or four sides but ordinarily accept any species. Unconsequently, many inferior woods are used. However, maría and capá blanco, generally considered good species, appear to be used more than others. None of the native ties are given preservative treatment.

Table 7.—Annual use of crossarms and brackets in Puerto Rico

Description	Quantity	Average cost	Total cost
<hr/>			
Crossarms	Number	Dollars	Dollars
16 pins - 120 inches long	446	2.92	1,302
10 pins - 94 inches long	1,950	2.89	5,635
8 pins - 82 inches long	10	1.36	14
6 pins	2,768	2.41	6,677
4 pins	6,848	1.93	11,286
2 pins	2,000	1.00	2,000
4 x 5 inches x 10 ft.	1,612	3.59	5,787
6 x 6 inches x 20 ft.	22	13.47	296
6 x 6 inches x 25 ft.	200	17.44	3,488
6 x 6 inches x 30 ft.	308	24.20	7,454
Miscellaneous	32	2.37	76
<hr/>			
Subtotals	16,196		44,009
Brackets (all types)	16,430	0.96	1,577
Totals			45,586

Table 8.—Crossties used annually by railroads and sugar companies.^{1/}

Species or source	Quantity of ties	Total volume	Value per tie	Total value
	Number	M b. m.	Dollars	Dollars
Southern yellow pine	87,700	1,900	3.25	285,025
Cypress	18,700	430	2.00	39,600
Dominican Republic woods	8,000	190	2.00	16,000
Native woods	15,100	320	1.00	15,100
Totals	129,500	2,840		355,725

1/ Based upon 1953 survey by Miguel Hernández Agosto.
2/ Weighted average.

Prices for ties of native woods vary from \$30 per thousand board feet for 8 x 8 x 72-inch ties hewn on two sides to \$128 for 6 x 6 x 72-inch ties hewn on four sides. One company uses 3,500 5 x 5 x 60-inch ties hewn on two sides (approximately 10 bd. ft. each) annually at a cost of \$63 per thousand board feet or \$0.63 each. Another large user of ties hewn on four sides pays \$52 per thousand board feet for 6 x 6 x 72-inch ties and \$62.50 per thousand board feet for 96-inch ties of the same size, amounting to \$1.25 and \$2.00 per tie respectively. The average price paid for native ties is approximately \$1.00 each.

Three companies use only red or black tidewater cypress ties, containing 85 percent or better heart, that are manufactured in accordance with standard railroad specifications for No. 1 ties. The price c.i.f. San Juan varies according to the size; 5 x 6-inch x 5-foot ties cost \$1.59 each or \$106 per thousand board feet; 6 x 8-inch x 7-foot ties cost \$2.38 each, or \$85 per thousand board feet; and 6 x 8-inch x 6-foot ties cost \$2.21 each or \$92 per thousand board feet. The average price amounts to about \$2.00 per tie.

Southern yellow pine ties are used exclusively by 14 sugar companies and by both common-carrier railroads in Puerto Rico. The average price of a treated 6 x 8-inch x 6-foot yellow pine tie, c.i.f. San Juan or Mayaguez, runs about \$150 per thousand board feet or an average of about \$3.25 per tie.

Treated yellow pine ties are replacing all other species and may soon be the only type

used in Puerto Rico. Metal ties from Belgium and France have been tried and abandoned. Untreated redwood ties have also been tried and found to be inferior to treated yellow pine.

All yellow pine ties are treated before shipment from the United States. Pressure treatment to obtain retentions of not less than 8 pounds of No. 1 creosote oil per cubic foot is the lowest requirement in effect. Most users require not less than 10-pound retention and several sugar companies and the largest railroad require a 12-pound retention. The trend is toward the use of heavier retentions, thereby increasing the initial cost but reducing the frequency of replacement. Some switch tie and bridge material is treated to a retention of 16 pounds per cubic foot.

Treated southern yellow pine ties have a service life of about 15 years in the track-age of the sugar companies and from 15 to 20 years in lines of the Puerto Rico Railroad and Transportation Company. This company reports tie failures are mostly due to mechanical wear and weathering rather than decay. Replacements on the smaller Ponce and Guayama Railroad and three affiliated sugar companies are thought to be equally due to rot and mechanical failure. Replacements by most other sugar companies appear to be the result of decay.

Untreated cypress ties last about 8 years but may fail after a period as short as 2 years due to lack of heartwood or, at the other extreme, may sometimes last up to 18 years. Some early replacements are due to mechanical failures.

Ties from the Dominican Republic (bayahonda, candelón and moralón) are reported to last from 5 to 20 years when hewn on two sides and up to 30 years when hewn on four sides. Perhaps 10 to 12 years would be a reasonable average. Bayahonda and moralón ties are exceedingly hard and must be prebored and framed for the tie plate installation. Shipments also often contain inferior species and frequently contain considerable sapwood which is not durable.

According to several of the sugar companies, the Dominican ties have a tendency to split when used along the dry southern coast.

Native ties ordinarily last from 2 to 4 years. Ucar, and capá blanco are reported to last 6 to 8 years and maría 5 years but the average is likely somewhere around 3 years. Ties hewn on four sides have lost most of their sapwood and resist decay longer than those hewn on only two sides. However, the added service life may not always justify their greater cost. When all factors are considered, the railroads and sugar companies cannot afford to use anything but treated yellow pine ties. This is, of course, the reason for the declining use of other species. The trackage owned by sugar companies is expected to continue to decrease but at a reduced rate. A further reduction of trackage will naturally reduce tie purchases accordingly. The use of native ties can be expected to decline even further unless a modern treating plant is installed and pressure treated native ties are available.

CRATING AND BOXING FOR EXPORT

None of the several hundred factories visited during the survey were using any appreciable quantity of wooden shipping containers or crates. A few plants use small amounts of wood for occasional shipments and others use some scrap material or used boxes but practically all manufactured items are shipped in paper containers. The survey results indicate not more than 50,000 board feet of yellow pine was used for this purpose during 1954. The total wood use is so small that it is not considered further in this report. Many fragile items, including table lamps, radio parts, drafting instruments, cosmetics, rum, dishes, glassware, etc. are shipped in paper boxes except on rare occasions where a military contract or other purchaser specified wooden boxes. Other products are sometimes packed in large metal boxes or containers furnished by the steamship lines. Most concerns that have tried boxing or crating have used southern yellow pine with very un-

satisfactory results as it is wet, heavy, splits easily, hard to work, and expensive in the grades required. White or western pine makes good boxes but is too expensive for most uses. It appears that no products requiring wooden shipping containers are profitable items in Puerto Rico industry. At least such items are rarely exported from the island.

The amount of wood used annually for boxing household furniture and occasionally other items is estimated at 1,134,000 board feet, valued at more than \$136,000. Two concerns box practically all furniture leaving the island, including shipments for the armed services. The lower grades of yellow pine are used at a cost of about \$120 per thousand board feet. Table saws are used for cutting material to size but no nailing machines are used. The increased use of metal shipping containers and the recent inauguration of "roll on-roll off" trailer van shipment to the States may appreciably reduce the need for wood in crating household goods.

BURIAL BOXES

Most burials in Puerto Rico are made in wooden coffins. However, some metal caskets are imported and others are manufactured locally. A rapid and consequently not too reliable survey of the industry indicates that about 450,000 board feet of lumber, 290,000 square feet of plywood and 40,000 board feet of salvaged materials are used annually in coffins at a total annual cost of nearly \$130,000 (Table 9). Burial boxes are usually made in small shops operated in conjunction with the individual mortuaries. A few burials are made in expensive mahogany caskets constructed of solid mahogany except for the bottoms which are either mahogany or baboen plywood.

Most burial boxes are made of Douglas-fir or pine lumber and Douglas-fir plywood. They are either constructed entirely of plywood on light pine interior framing or with solid lumber sides and ends and the tops and bottoms of plywood, covered inside and out

with fabric. Quite often to facilitate economical use of material the sides fail to meet the bottom by 1 or 2 inches which is not visible after the exterior fabric is attached. Low cost handles are installed or sometimes special carrying handles are used and removed at the burial site. Wood waste is very low in this type of manufacture. With the exception of those made of mahogany, burial boxes are as cheaply made as circumstances allow. Some coffins are made with scrap lumber of boxes or crates salvaged from import shipments. Coffins of this type, sometimes with paperboard bottoms, sell for as little as \$8.00.

Table 9.—Estimated annual use of lumber for burial boxes^{1/}

Material and species	Volume	Value per unit	Total value
		Dollars	Dollars
Lumber - M.b.m.			
S.Y. pine	50	130.00	6,500
Douglas-fir	160	120.00	19,200
Mahogany	200	300.00	60,000
Paraná pine	40	185.00	7,400
Sub-total	450		93,100
Plywood - M. sq. ft.			
Douglas-fir	250	120.00	30,000
Baboen	25	135.00	3,375
Mahogany	15	200.00	3,000
Sub-total	290		36,375
Salvage material -			
M.b.m.			
Misc. box and Crating	40	—	—
Grand Total			129,475

^{1/} Based on 22,000 burials per year. Data are based on a few scattered contacts and must be considered as rough estimates.

PALLETS

Pallets, which are simply platforms or bases on which goods or materials can be stacked for easy movement by fork-lift trucks, are used nowadays by many of the more progressive plants in the United States and throughout the world as an efficient and economical way to move and store materials and products. Most pallets are of wood, although all-metal pallets can be purchased.

Palletizing makes it possible to lift and move or stack for storage a large quantity of material at one time. The use of pallets has been adopted in a few sugar companies and other large plants in Puerto Rico and by all steamship lines to some extent. The trend is toward greater use of pallets by both large and small industries moving relatively large quantities of material.

About 7,000 wooden pallets of all types and sizes were purchased in 1953, including a small volume of material used to repair damaged pallets. Oak and hickory made up nearly 85 percent of the 285 M board feet of lumber used during 1953. Nicaraguan pine and southern yellow pine comprised the other 15 percent. About 80 percent of the pallets or pallet material was purchased in the United States and the remainder were built by the steamship lines of used dunnage.

The most popular pallet is the flat type having both bottom and top decking. Deck boards are usually of 1-inch thickness and 4 to 10 inches wide with a 1- to 3-inch spacing between boards. Stringers, usually three but at times up to five per pallet, vary from 2 x 3 inches to 4 x 4 inches in cross section, depending on the size of the pallet and loads to be carried. Some concerns prefer pallets with decking boards extending past the stringers and others prefer flush sides. Steamship lines use principally 5 x 7-foot pallets, while processing and manufacturing companies generally use smaller pallets from 3 x 4 to 4 x 6 feet in size. Cement-coated drive screws, lag bolts, carriage bolts and common nails are used as fasteners. Some pallets are treated before shipment to resist rot, insects and warping. The cost of pallets varies according to size, material, fasteners, and design. Oak pallets of 4 x 5-foot dimension are purchased in lots of 1,000 for as low as \$6.00 each, delivered in San Juan. Oak and hickory pallets of 4 x 7½-foot dimensions with special drive screws fasteners have been purchased for \$16.00 each c.i.f. San Juan in lots of 250. However, the average hardwood pallet used in Puerto Rico probably costs from \$10.00 to \$12.00 delivered.

Shipping companies experience heavy breakage in pallets, necessitating frequent replacement or repairs. It appears that most breakage is due to misuse of the pallets, principally overloading and mishandling. Some pallets are not designed for the loads they carry or are too lightly fastened to withstand the heavy loads. Other failures are due to being dropped on a corner or side or by other careless handling with lift trucks. If normal care is exercised a well designed pallet can be used for several years without need of repair or replacement.

BROOM AND MOP HANDLES

More than 880,000 brooms were produced in Puerto Rico during fiscal year 1954. Some 600,000 of this number were made with imported Douglas-fir handles and at least 200,000 were made with handles of native wood. There were more than 30 producers of brooms at the time of the survey which are largely concentrated in the Aguadilla-Aguada and Isabela-Quebradillas districts except for one large and two small producers in the San Juan area. Two factories produce nearly one-half of the better quality brooms with fir handles. The remainder are made by family units working under primitive conditions. All brooms with native wood handles are made by family units.

Douglas-fir broom handles are 42 inches long, 7/8-inch in diameter and cost from \$55.00 to \$60.00 per thousand, unpainted. Varnished handles cost about another \$10.00 per thousand but are seldom used. Most handles come from one concern in western Oregon although a few are imported from Cuba. Some \$32,000 was expended during the year for these handles. Native wood handles are also 42 inches long and approximately 1 inch in diameter. They are supplied locally with the bark intact for \$12.00 per thousand. Any species that is of the correct size and length and reasonably straight is accepted and a single small shipment may include 10 to 20 species of wood.

Broom straw is imported from Cuba, the Dominican Republic and the Orient and used with fir handles in brooms that sell wholesale at \$2.00 per dozen. Fronds of the native broom palm are used with the native handles to make brooms that sell at \$1.00 per dozen wholesale. A few better quality brooms made by two concerns in the San Juan area command a somewhat better price. It appears that manufacture of brooms of native material is not sufficiently profitable to hold the interest of producers except as a stop gap source of income. The supply of native broom palm fronds may also be a limiting factor.

TRANSPORTATION EQUIPMENT

Station-wagon bodies, truck beds and racks and ox-carts are repaired in numerous small shops scattered throughout the island. Several were located and interviewed but no attempt is made to estimate their total wood use due to the lack of data on the number of shops operating in Puerto Rico. However, it is apparent that the use of wood for these purposes is declining very rapidly. Station-wagon bodies once made entirely of wood are now largely metal and wooden ox-carts are being replaced by all-metal rubber-tired carts. Repair shops that formerly employed as many as 10 to 12 men are now operated by one or two people on an intermittent basis; in many cases only the owner remains.

A number of local species are used for repair work in addition to small quantities of imported Nicaraguan pine, Dominican pine and white oak. Native species include ucar, capá prieto, algarrobo, capá blanco, roble, guaraguo, maría, ausubo and guamá. Squared logs are usually purchased and worked up as the need develops for different size pieces. Most logs are purchased green and used in that condition. In some isolated instances spokes and other items are roughed out and allowed to dry before the final shaping.

Capá blanco and algarrobo are preferred for wheel parts of ox carts and capá prieto for the frames. Most any of the hard dense native species are acceptable for station-wagon

body repairs and truck beds although pine is generally used nowadays in truck beds and oak is occasionally used in station-wagon repairs. The imported Dominican and Nicaraguan pines and oak are gaining in popularity as they are dry, sized, and uniform in grade.

Squared logs of native species are bought at prices ranging from \$100.00 per thousand board feet for roble and guaraguao to \$300.00 for ucar, capá prieto and algarrobo, although the price paid by different shops may vary as much as \$150.00 per thousand board feet. Dominican and Nicaraguan pine costs about \$160.00. Most repair shops would prefer dry, well manufactured native woods over imported species and would be willing to pay a reasonably high price for good species. However, except for truck beds and racks, the use of both imported and native wood will continue to decline.

MISCELLANEOUS WOOD USES

Miscellaneous uses of wood and wood products by industries in Puerto Rico are summarized in Table 10 and described in the following paragraphs.

Household Items

One concern used 80,000 board feet of southern yellow pine during fiscal year 1954 to build low cost ironing boards, wash boards, and coat hangers. Another manufacturer used a few hundred board feet of yellow pine lumber for frames in sabutan covered screens.

As much as 20,000 board feet of native woods is used annually in mortars and pestles. Small round wood poles or logs 8 to 12 inches in diameter of roble, guayacán, and other species are used. With the exception of one large producer in Aibonito, all mortars and pestles are produced by one- and two-man shops. One concern is using about 1,000 board feet of mahogany annually in lamp bases.

Marine Repairs

One privately owned dry dock is operating in the Metropolitan area. Annual timber use includes an estimated 150 thousand board

feet of yellow pine, 3,000 feet of cypress, 3,000 feet of greenheart, 2,000 feet each of oak and mahogany lumber, and about 5,000 square feet of mahogany plywood. Small quantities of other woods are used at intermittent intervals.

Textiles

Three of the concerns operating textile machines use wooden accessories. Dogwood shuttles, maple bobbins of several types, and hickory picker sticks, loom harnesses, box swells, jack sticks, and power blocks are imported from the United States. About \$17,000 are spent annually in these items. One company is using loom harnesses made of native guaraguao which are reported to be as satisfactory as those made of hickory.

Twine Reels

About 36,000 reels made of red and white oak are imported annually from the United States in three sizes suitable to hold 10, 50 or 100 pounds of twine. Reel material, delivered "knocked-down" for assembly in Puerto Rico, cost an average of 38 cents per reel.

Stone Cement and Clay Products

Stickers and drying crates are used in the manufacture of cement blocks and ceramic tile, requiring about 90,000 board feet of yellow pine annually. About 5,000 feet of cypress is also used by one clay tile manufacturer for even boards. Cypress, according to experience, withstands oven heat better than other woods.

Cigar Boxes

The manufacture of both hand-rolled and machine-made cigars is a big business in Puerto Rico, requiring millions of boxes. However, except for about 17,000 wooden boxes, all cigars are packaged in paper or cardboard boxes or in paper wrappers. Wooden cigar boxes made of mahogany or cedar cost from 20 to 40 cents assembled as compared to 15 to 18 cents for a good paper-board box or 2-½ cents for a paper box. This price differential is, of course, the principal reason

why so few cigars are boxed in wood. Some 13,400 redwood boxes were used last year by one concern at a cost of 20 cents each. About 3,000 Mexican cedar and mahogany boxes were used by another concern plus approximately 400 fancy mahogany gift boxes costing an average of \$4.00 each. Wooden cigar boxes are preferred to paper boxes if available at a comparable price. Any fairly dark wood with a pleasant odor would be acceptable; mahogany, cedar or redwood are not necessarily preferred if other suitable woods are available. However, cigar manufacture is a volume business and a saving of two or three cents per box is very important.

Printing

The printing industry requires black cherry blocking for the backs of plates and sugar maple knife cushions in paper cutters. Other woods may be as suitable but cherry is the only species accepted by the industry for blocking because of its stability, workability and other favorable characteristics. Blocking is imported from the United States in 12 to 24 and 24 x 30-inch blocks or $\frac{3}{4}$ -inch thickness composed of glued-up strips 2 to 4 inches wide. About 4,000 board feet are used annually at about \$700 per thousand board feet. There may be native woods which would be entirely suitable for this use. An estimated 9,600 knife cushions of 1 x 1 x 40-inch size are used annually at a cost of about 30 cents each. Many local species would meet the requirements for this use.

Rug Weaving

Several large plants manufacturing hand woven rugs use annually an estimated 4,000 board feet of walnut and a small amount of laurel sabino each year for rug needles. Rug needles must be made of a hard smooth wood which does not splinter or wear easily. Both walnut and laurel sabino are reported to give satisfactory service. Walnut costs about \$500 and laurel sabino \$400 per thousand board feet. About 10,000 board feet of yellow pine and 4,000 board feet of oak are used annually for rug frames, truck beds and other uses.

Art Brushes

One manufacturer is using an estimated 3,750,000 wooden handles for art brushes annually. About 75 sizes and types of maple, beech, birch and pine handles are imported from Germany and the United States. A serious problem is caused by the change in relative humidity from Puerto Rico to heated buildings in the United States which causes the wood to shrink and the metal ferrules to loosen. One solution is to install ferrules only on very dry handles but adequate drying equipment to do this has not yet been installed. Another solution would be to impregnate the wooden handles with one of the resin solutions which retard shrinkage or swelling of wood in response to changes in atmospheric conditions.

Leather Tanning

One of the leather tanneries in Puerto Rico uses up to 5,000 board feet of yellow pine annually in tacking boards for stretching skins and another 5,000 board feet of the same species to box tanned hides for export to the United States. The other concerns tanning leather do not use wooden tacking boards or shipping boxes.

Canning Factories

An estimated 5,000 feet of southern yellow pine is used annually for trays in canning factories. Some canneries use only metal trays while others use wooden trays made of scrap or salvage material.

Metal Castings

About 4,000 board feet of southern yellow pine is used annually to build mold forms for metal castings, a field which is not developed to any extent in Puerto Rico.

Fishing Rods

Tonkin cane from China, "ski" hickory from the United States and snakewood from Cuba are used by one manufacturer of fishing rods. High quality pieces of split tonkin cane 6 feet long by 1 to 2 inches wide are imported at 40 cents each, f.o.b., New York.

Table 10.—Estimated annual wood use by miscellaneous industries

Industry and use	Species	Units	Cost per unit delivered	Total cost
		Number	Dollars	Dollars
Household Items:				
Wash boards, ironing boards	S.Y. pine	80 M.b.m.	130.00	10,140
Coat hangers	S.Y. pine	2 M.b.m.	130.00	260
Mortars and pestles	Native	20 M.b.m.	100.00	2,000
Table lamps	Mahogany	1 M.b.m.	300.00	360
Patented item	Douglas-fir	2,500 M.sq.ft.	110.00	275,000
Dry-dock (Marine)	S.Y. pine	150 M.b.m.	130.00	19,500
	Cypress	3 M.b.m.	350.00	1,050
	Greenheart	3 M.b.m.	300.00	900
Ship repairs	Mahogany	2 M.b.m.	350.00	700
	Oak	2 M.b.m.	380.00	760
	Mahogany	5 M.sq.ft.	500.00	2,500
Textiles				
Shuttles	Dogwood	3,700 each	2.50	9,250
Bobbins	Maple	22,200 each	.26	5,772
Picker sticks	Hickory	3,400 each	.50	1,700
Loom harness sets	Hickory	25 each	1.00	25
	Guaraguao	200 each	1.00	200
Power block	Hickory	100 each	.70	70
Jack stick	Hickory	50 each	2.90	145
Twine Manufacture				
Reels	W. & R. Oak	36,000 each	.38	13,680
Stone, Cement and Clay Products				
Stickers & Drying crates	S.Y. pine	90 M.b.m.	130.00	11,700
Oven boards	Cypress	5 M.b.m.	300.00	1,500
Cigar manufacture				
Boxes, standard	Redwood	13,400 each	.20	2,680
Boxes, standard	Mahogany and cedar	3,000 each	.40	1,200
Boxes, gift	Mahogany	400 each	4.00	1,600
Printing				
Blocking	Black cherry	4 M.b.m.	700.00	2,800
Knife cushions	Sugar maple	9,600 each	.30	2,880

Industry and use	Species	Un'ts	Cost per unit delivered	Total cost
Rug Weaving				
Needles	Walnut	4 M.b.m.	500.00	2,000
Frames, etc.	S.Y. pine	10 M.b.m.	130.00	1,300
	Oak	5 M.b.m.	150.00	750
Art Brushes				
Brush handles	W. birch	3,750,00 each	?	?

Hickory and snakewood are used for handles. Snakewood, a wood resembling ebony, is bought in Cuba in 6-foot logs of 6 to 8 inches diameter for \$2.00 per log. Data on quantities used annually were not available.

Signature Blocks

One individual makes signature blocks (name plates for desks) out of maga and capá blanco using, according to his estimate, about 2,000 feet of each species annually. The market is much greater than he can supply as he works principally with small hand tools.

CONCLUSIONS

The survey of industrial wood use in Puerto Rico and the summarization of the findings in this report allow the formation of a number of pertinent conclusions, some of them confined entirely to the field covered in the survey and others of more general application to the entire field of wood use in Puerto Rico; they are as follows:

1. The industrial requirements for wood products in Puerto Rico are increasing rapidly under the government's industrial and agricultural development program. Lumber and plywood, principally from Mexico, the United States, Canada and Surinam are filling this requirement.
2. The use of locally grown wood has declined to a point where it is of little importance to the industrial economy of the island. A continued decline is expected.
3. Locally grown wood has been replaced by imported material because of (1)

insufficient supplies; (2) intermittent and unreliable supplies; (3) unfavorable prices due to antiquated logging and milling facilities, the heterogeneous character of the forests, and high transportation costs; (4) lack of uniformity in dimension and grade of material available; (5) preference for kiln-dried or properly air dried wood; and (6) the requirements by some users for a wood resistant to termite attack.

4. It is clearly evident that any increase in the use of native wood must be preceded by the adoption and use of more efficient logging practices and equipment and the establishment of adequate milling equipment.
5. There is an almost complete lack of knowledge concerning the drying and care during conversion of native lumber and the storage of imported material. Much of the loss during manufacture is a result of improper drying and storage.
6. The use of native wood is suffering because of the lack of preservation and kiln-drying facilities. In addition, a large portion of the imported wood is giving only a fraction of its service life, for the same reason. At least one modern preservation plant and one or more dry kilns are required to meet the immediate needs.
7. The local market will use large quantities of native wood whenever it becomes available in reasonable quantities and is comparable in grade, con-

dition and price to imported material. Many concerns express a preference for native woods under the above conditions.

8. Most industrial uses of wood are such that native wood could be used in place of imported material and in some industries would be more satisfactory than the present supplies.
9. Large quantities of mahogany are used for hidden parts of furniture and other uses where other less valuable hardwoods would be satisfactory, particularly when treated to repel termites.
10. Most industrial users of wood, particularly in the furniture and millwork fields, are too small and lack the proper equipment, financing, working space and managerial ability to operate efficiently.
11. Wood residue is not particularly high but a sizeable portion of this loss could be prevented or recovered by better operating procedures and the development of uses for scrap material.
12. The costs of lumber and plywood and the retail costs of the products, particularly furniture, appears to be a severe handicap to the industry. Reducing material costs, along with an increase in plant efficiency through better equipment, specialization in products, better working conditions (plant housing) and good management would do much to alleviate this condition.
13. Marketing of millwork and furniture is unorganized and, in general conducted on a "hand-to-mouth" basis which is detrimental to the economic status of the producers of these products.
14. There is little possibility of exporting furniture and other products made of wood to the United States and other areas in the temperate zone until local kiln drying facilities are available.

Plant efficiency and product design would also need improvement.

15. Wood might regain part of the market lost to metal and glass in the millwork field if adequate preservation facilities were available.
16. A large, well equipped box plant in Puerto Rico would be in a favorable position to supply a large portion of the \$500,000 in fruit and vegetable containers and soft drink cases required each year in Puerto Rico.
17. A large portion of the 17,000 utility poles used annually on the island might be produced locally from Australian pine and Eucalyptus. Tests as to their treatability and durability would be required as well as the installation of a suitable preservation plant.
18. The present forests could furnish most if not all of the crossties used by the railroads and sugar refineries if adequate conversion and preservation facilities were available.
19. It is a good possibility that sufficient rattan could be grown locally to meet the present but expanding requirement of 750,000 lineal feet per year.

SUMMARY

A survey of industrial wood use in Puerto Rico was conducted by the Tropical Forest Research Center during 1954. More than 600 industrial concerns including those handling agricultural products, were visited during the survey. The results showed that the forests of Puerto Rico contribute less than 2 percent of the wood currently used by industries and probably less than 1 percent of all sawed or hewed forest products used on the island.

According to the survey less than 850 M board feet of native lumber, ties, and other hewed or sawed products are used annually. This volume is used almost exclusively for furniture (316 M bd. ft.), farm buildings (estimated at 200 M. bd. ft.) and hewed railroads ties (320 M bd. ft.). Sizable quantities of posts, poles and fuelwood or charcoal

are also used on the farms. An additional 80 to 90 million board feet of lumber and other wood products is imported annually to meet the total requirements of the island.

The use of native wood by industry has declined in favor of imported woods. Many local species are equal or superior to the imported material but because of improper manufacture are not acceptable for many uses. This is primarily the result of antiquated logging and milling methods and the absence of preservation plants, dry kilns and other conversion facilities. Except for mahogany from Mexico, nearly all wood is imported from the United States and Canada.

Much of the dissatisfaction with native woods results from a lack of information concerning their qualities and proper utilization. Certain good quality woods give poor service because of improper use. Others are not utilized due to the lack of local knowledge of their properties, although often giving satisfactory service in other tropical areas. This overall problem points up the immediate need for research on the utilization of locally grown woods.

It is also apparent that only a small portion of the manufacturing industry requires or is using wood in any form. Industrial wood use is almost entirely in the manufacture of products for local consumption. Virtually all export packaging except for fruit, vegetables, and household goods consists of paper containers, despite heavy damage during transit and increased transportation costs by air shipment of fragile items.

Furniture is manufactured by some 206 concerns in Puerto Rico, employing 2,800 people on a year-long basis. It is the largest industrial use of wood, requiring some 7.6 million board feet of lumber and 3.3 million square feet of plywood annually. About 5.2 million feet of this volume is mahogany lumber and 2.5 million square feet is baboen plywood^{2/}. Approximately 560,000 square feet of mahogany and cedar plywood is also used.

The small amount of native wood used is largely tabonuco, guaraguao, capá prieto, laurel sabino and cedro. Both native woods and imported mahogany lumber are generally degraded through improper drying and storage methods. Baboen and other woods susceptible to insect attack are seldom treated with preservatives. Wood residues represent a waste of \$330,000 annually. The use of native hardwoods involves an average waste during manufacture of 24 percent, compared to 14 percent for mahogany. Some of this loss is unavoidable but a portion could be prevented or salvaged by improved manufacturing methods.

Millwork is produced by 38 concerns in Puerto Rico, which used an estimated 1,657 million board feet of lumber and 335,000 square feet of plywood during fiscal year 1954. About 70 percent of the lumber is southern yellow pine, mahogany, cypress, and red cedar. Baboen and Douglas-fir constitute 85 percent of the plywood used. Mahogany, cedar, okoume and banak provide the remaining 15 percent. Native wood is not used in this industry.

More than 650,000 wooden containers of all types, valued at over \$300,000, were used for shipping fruit and vegetables during 1954. The demand for this type of container is increasing steadily. Over 170,000 wooden soft drink cases are used annually at a total cost in excess of \$175,000. Some 17,000 utility poles, valued at nearly \$650,000 and an estimated \$46,000 in brackets, pins and cross-arms are used annually. All poles and cross-arms are pressure treated southern yellow pine; brackets and pins are made of both treated southern yellow pine and oak.

Although the need for crossties has declined along with the reduction of trackage maintained by sugar companies, 130,000 ties are still required annually, at a total cost of \$350,000. All ties used on the island were at one time supplied by the local forests and from the Dominican Republic. However, more than 80 percent of the ties purchased in 1954 were pressure treated southern yellow

2/ Scientific names listed in the appendix.

pine or untreated cypress. Trackage and crosstie requirements are expected to decline further.

Large quantities of southern yellow pine are used in boxing household goods for overseas shipment requiring more than 1.1 million board feet of nominal 1-inch lumber during 1954. The use of metal shipping boxes and movement of household and manufactured goods by "roll-on-roll off" trailers may effectively reduce the need for lumber in this field.

Most burials are made in wooden caskets which range in quality from expensive highly polished mahogany to low cost pine, plywood

and paperboard. The majority of these caskets are made in small shops that are operated in conjunction with the individual mortuaries. It is estimated that over 90,000 board feet of lumber and 35,000 square feet of plywood are required annually.

The use of pallets is increasing. About 7,000 were purchased or constructed by the larger concerns in 1954, requiring about 285,000 board feet of lumber. Oak and hickory were the principal woods used, plus some yellow pine, Caribbean pine and dunnage of various species. More than 800,000 broom and mop handles are used annually. About 600,000 of these are imported from Oregon, the other 200,000 are of native wood.

APPENDIX

Common and Scientific Names of Woods Mentioned in the Text

Common Name	Scientific Name
Algarrobo	<i>Hymenaea courbaril</i> L.
Ash	<i>Fraxinus</i> spp.
Ausubo	<i>Manilkara bidentata</i> (A.DC.) Chev.
Baboen	<i>Virola surinamensis</i> (Rol.) Warb.
Bamboo	<i>Bambusa</i> spp.
Banak	<i>Virola koschnyi</i> Warb.
Bayahonda	<i>Prosopis juliflora</i> (Sw.) DC.
Birch, Yellow	<i>Betula alleghaniensis</i> Britt.
Blackgum	<i>Nyssa sylvatica</i> Marsh
Caimitillo	<i>Micropholis chrysophylloides</i> Pierre
Candelón	<i>Senegalia angustifolia</i> (Lam.) Britt & Rose
Capá blanco	<i>Petitia domingensis</i> Jacq.
Capá prieto	<i>Cordia alliodora</i> Cham.
Ceboruquillo	<i>Thouinia striata</i> Radlk.
Cedar	<i>Cedrela mexicana</i> Roem.
Cedar, Mexican	<i>Cedrela mexicana</i> Roem.
Cedro	<i>Cedrela odorata</i> L.
Cedro macho	<i>Hyeronima clusioides</i> (Tul.) Griseb.
Cherry, Black	<i>Prunus occidentalis</i> Sw.
Cottonwood	<i>Populus deltoides</i> Bartn.
Cypress	<i>Taxodium distichum</i> (L.) Rich.
Douglas-fir	<i>Pseudotsuga menziesii</i> (Mirb.) Franco
Elm	<i>Ulmus americana</i> L.
Enea	<i>Enea</i> sp.
Eucalyptus	<i>Eucalyptus</i> spp.
Greenheart	<i>Ocotea rodiaei</i> (Schomb.) Baker
Guamá	<i>Inga laurina</i> (Sw.) Willd.

Guaraguao
 Guayacán
 Hickory
 Higuerillo
 Hoja menuda
 Jagua
 Jaguilla
 Laurel, bobo
 Laurel geo
 Laurel sabino
 Mahogany, African
 Mahogany, Honduras
 Mahogany, Mexican
 Mahogany, Philippine
 Mahogany, West Indies
 Maga
 Maple, Sugar
 Maria
 Moralón
 Nuez Moscada
 Oak, Red
 Oak, White
 Okoume
 Pandanus
 Pine, Australian
 Pine, Dominican
 Pine, Nicaraguan
 Pine, Paraná
 Pine, Southern Yellow
 (Yellow) (Pitch)
 Pine, Western White
 Quebra hacha

 Redwood
 Roble
 Snakewood
 Spruce
 Tabonuco
 Tortugo
 Ucar
 Walnut, Black

Guarea trichilioides L.
Guaiacum officinale L.
Carya ovata (Mill.) K. Koch
Vitex divaricata Sw.
Myrcia spp.
Genipa americana L.
Magnolia portoricensis Bello
Phoebe elongata (Vahl.) Nees
Ocotea portoricensis Mez
Magnolia splendens Urban
Khaya ivorensis A. Chev.
Swietenia macrophylla King
Swietenia macrophylla King
Shorea spp.
Swietenia mahagoni Jacq.
Montezuma speciosissima Sessé & Moc.
Acer saccharum Marsh.
Calophyllum calaba Jacq.
Cocoloba uvifera L.
Ocotea moschata (Pavon) Mez
Quercus rubra L.
Quercus alba L.
Aucoumea plaineana Pierre

Casuarina equisetifolia Forst.
Pinus occidentalis Sw.
Pinus Caribaea Mor.
Aracauria angustifolia (Bertol.) O. Kuntze
Pinus echinata Mill. *P. taeda* L.
P. palustris Mill. *P. elliotii* Engelm.
Pinus monticola Dougl.
Pseudocopaiva hymenaeifolia (Moric.) Britt.
 & Wils.
Sequoia sempervirens (D. Don) Endl.
Tabebuia pallida Miers
Piratinera panamensis Pitt.
Picea spp.
Dacryodes excelsa Vahl.
Sideroxylon foetidissimum Jacq.
Bucida buceras L.
Juglans nigra L.

THE INSECTS OF "ALMENDRÓN", PRUNUS OCCIDENTALIS SW.

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The "Almendrón" of Puerto Rico, Santo Domingo and Cuba, *Prunus occidentalis* Swartz, is an endemic tree of the mountain areas of both the Greater and the Lesser Antilles. The smooth-skinned, dark purplish fruit is shaped like a small prune, which in Puerto Rico matures in mid-June. Although edible, it is hardly to be recommended for human consumption as all collected locally have been heavily infested with the maggots of the fruit-fly, *Anastrepha suspensa* Loew. (This is the fruit-fly which at lower elevations attacks the fruit of guava, pomarrosa, the husks of almendro and the over-ripe grapefruit and oranges). In Martinique, a liqueur is prepared from the fruit of the almendrón: the locally celebrated Noyau.

The economic importance of the almendrón does not depend on its fruit, but on its wood, which although not adapted for use outdoors exposed to the weather, is hard and durable and is more resistant than the heartwood of genuine West Indian mahogany, *Swietenia mahagoni* Jacq., to the attack of the "polilla", *Cryptotermes brevis* Walker. So few are the timbers of Puerto Rico which are more resistant than mahogany, that each one merits especial attention. The entomologists have been making observations on a nursery of trees discarded by the Forest Service and now 6 to 9 feet high, located below the swimming pool of the Doña Juana Recreation Area of the Toro Negro Unit. Almendrón trees are not outstandingly conspicuous, either individually or en masse, and the plain oval leaves vary so considerably in size as to not be distinctive. Rarely one may find on an otherwise uninjured leaf what looks like a spot of undried black paint, its surface somewhat interrupted by scattered pustules. Submitted to Mr. John

A. Stevenson of the Mycology and Disease Survey of the Plant Industry Section at Beltsville, Maryland, this unique fungus was identified by Dr. Wm. W. Diehl as *Rhytisma leptospilum* Berk. et Curt. Unfortunately, it is not merely a very interesting mycological specimen, for Mr. José Marrero a few months ago found it attacking not only leaves, but twigs and stems of seedlings in a nursery at higher elevations.

A most beautiful vaquita, black striped with iridescent scales of blue green, of which a single female was found ovipositing between coffee leaves at Maricao in 1921, was described in "Insectae Portoricensis" as *Compsus maricao* Wolcott, and for some years constituted the only individual known. Since observations were started on the nursery of almendrón trees at Doña Juana, dozens of individuals of both sexes have been found, an indeed occur in such abundance that many of the seedlings have been largely defoliated. Bright yellow individuals of the common vaquita, *Diaprepes abbreviatus* L., are almost equally abundant, especially on the unshaded trees, and the combination of the two species constitutes a serious pest.

Several trees in the nursery are heavily infested with the common white scale of papaya, *Pseudalacaspis pentagona* (Targioni), and no predaceous lady-beetles have appeared spontaneously to check this outbreak.

The tender leaves of almendrón were noted last winter infested with two species of aphid: the green peach aphid, *Myzus persicae* (Sulzer), and in much greater abundance but causing no curling of the leaves, the spiraea aphid, *Aphis spiraeicola* Patch. No aphids have been noted during the Spring, Summer and Autumn, and even in the Winter their presence is so scarce as to be of little economic importance.

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